Vol. XX, Part I March, 1950

THE INDIAN JOURNAL OF AGRICULTURAL SCIENCE

Issued under the authority
of
The Indian Council of Agricultural Research

सत्यमेव जयते

Annual subscription
Rs. 15 or 23s. 6d.

Price per part
Rs. 4 or 6s. 6d.

PRINTED BY THE GOVERNMENT OF INDIA PRESS, CALCUTTA, INDIA,
PUBLISHED BY THE MANAGER OF PUBLICATIONS, DELHI.
1951

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VOL. XX, PART I

(March, 1950)

Original articles

ORIGINAL ARTICLES

RESEARCH INTO PROBLEMS RELATING TO COASTAL SOILS*

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(Received for publication on 20 November 1946)

(With one text-figure)

THE scheme of research, proposed by Prof. J. N. Mukherjee of the University of Calcutta, was sanctioned by the Indian Council of Agricultural Research in 1938. Work under the scheme began on September 1, 1939 under his guidance and supervision. The scheme terminated on March 31, 1945 at a total cost of Rs. 28,858-6-0. Besides the authors, Messrs. S. C. Das, T. D. Biswas and S. C. Chakravarty served under the scheme at one time or another.

Scope of work

The object of the scheme was to survey the coastal soils near about Barisal and some other selected places with special reference to the formation of pan soils which had been noticed by the Bengal Department of Agriculture. As the work proceeded, it was found difficult to arrange for transport and other facilities for work in the interior of the Bakarganj District and the work under the scheme was mainly restricted to the soils in the coastal area near and about Barisal. The soils of the island of Shahbazpur in the Bay of Bengal which lies in the District of Bakarganj were also examined. As an example of a third type of land, a small area in a shallow *bil* in Subarana Abad in the District of Khulna was taken up for the study of the soil profile.

Geographical and other features of the areas surveyed†

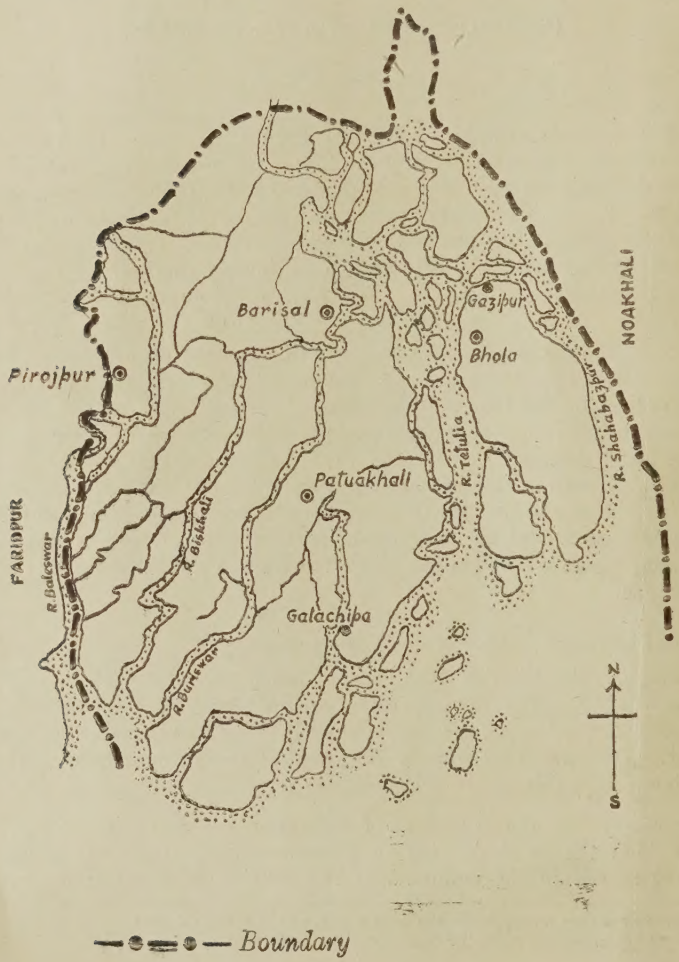
Bakarganj. The District of Bakarganj lies between 21°54′N and 23°2′N and 89°55′E and 92°2′E. The district with an area of about 4,891 square miles consists of two sharply defined parts, the mainland on the west and the island of Shahbazpur on the east. This part of the country has essentially a flat topography. The highest level is about eight feet above the mean sea level.

The river system of the District of Bakarganj, as shown in the map, is very important from the point of view of communication, transport, administration and drainage. Within the mainland of the district there are seven large rivers

* The present article incorporates the final report of the research work.

† Account taken mainly from the *Gazetteer of the Bakarganj District* by J. C. Jacks, 1913.

which flow generally in the north-east and the ramaining three in the south of the district. The rivers are tidal in these regions but fresh water is available at all times of the year. In the southern reaches of the rivers the water is salty, and most markedly so in the cold and summer seasons.



Drainage of such tracts is effected not only by rivers but also by numerous little water-courses known in Bengal as *khals* which combine to form bigger ones and open out into the river. Inside the district, especially in the west, there are beds of dead rivers or depressions filled with water which may or may not open during the rains or floods. These are locally known as *bils*. Some of them are quite large occupying hundreds of square miles.

The district is a typical region of the alluvial delta formed by the lower reaches of the Ganges and the Brahmaputra. A characteristic of many parts of this region is that the land surface is changing, old lands disappearing through river erosion and new ones are formed by fresh deposits of river-borne materials. The latter are called *chars* in Bengal. Some *chars* are short-lived as they sometimes disappear by river erosion. The area occupied by these *chars* varies widely.

Table I gives data for lower Bengal, kindly supplied by the Meteorological Office at Calcutta, which may be considered representative of the climatic conditions prevalent in the region surveyed. In some years, however, heavy showers occur in October due to storms in the Bay of Bengal. At times, the district experiences also wind squalls and cyclones.

TABLE I

Meteorological data for lower Bengal

Month	Temperature		Precipitation (inches)	Humidity
	Maximum	Minimum		
January	77·8	55·4	0·42	80·0
February	81·9	60·1	0·94	78·0
March	89·6	68·8	2·05	74·0
April	92·0	75·1	4·23	78·0
May	91·7	76·9	8·25	77·0
June	88·8	78·3	16·50	86·0
July	87·3	78·4	16·32	88·0
August	87·0	78·3	14·94	88·0
September	88·1	78·2	10·08	85·0
October .	87·6	74·9	6·14	81·0
November	83·2	65·6	1·54	78·0
December	78·1	56·6	0·25	82·0

Late paddy is usually sown alternately with pulses and chillies. Tobacco, sannhemp and jute are also grown in some areas. In the southern coastal region, in some places where *aus* (early paddy) and *aman* (late paddy) crops get ' burnt up ', to use the expression of local people, through salinity, bottle gourd and common gourd grow well. Betelnut and coconut grow satisfactorily in most of the areas. Samples of vegetation, mostly wild, occurring in some of the localities were collected. All of them were not, however, of equally extensive occurrence. Short grass (*Cynodon dactylon*) or motha (*Cyperus rotundus*) form the most common vegetation. A plant locally known as *euli* which has not been identified occurs widely only in recent *char* lands. Besides, there are *Gulum* (*Cucumis trigonus* Roxb.) and *Hatisunra* (*Herpestis monniera*).

Subarna Abad is near Satkhira in the District of Khulna and not far from the sea coast. Originally a *bil*, the land is situated at about two feet lower than that of the normal level of the water of the river against which protective embankments have been erected. There is, however, a variation of several feet in the level within the area which is also intersected by a number of canals. The west side of the landlord's office situated within the area and lands adjoining the sides of the canals and the bunds surrounding it have a comparatively higher level. Rain water is the source of the water supply for paddy. Normally, a type of valve arrangement is utilised to drain any excess rain water from the area and to prevent the entry of river water, although leakage and probably seepage enable some river water to enter the *khals* within the bunded area. However, if rains fail or are deficient, irrigation is done by water from the river. Drainage condition of the low lands is not good and water-logging in the rains is a common feature. Even in May the land is moist. The low lands shake when thumped heavily and it is said that in the rains cattle cannot move over these lands as they may sink in the swamp.

The climate of the area is almost the same as described for Barisal. The vegetation is mainly *shamla* (Panicum crus-galli Linn) grass and reeds. The original vegetation of the land, before it was cultivated for paddy, was a reed known in Bengal as *nalkhagra* (*P. Roxburghi* Kunth). The *shamla* grass is several feet high in the low lands. The grass is shorter in height in the comparatively speaking higher lands and in some places of this area which bear good crops it is absent and *dub* (*Cynodon dactylon*) is found instead.

Formation of char *lands*

Mainly three processes operate in the formation of a river delta, viz. transportation by water, deposition and stratification. Transportation by water here takes place only by suspension and solution. The capacity of a stream to carry load in suspension depends on the slope of the stream, the discharge the velocity, the shape, size and specific gravity of the materials, and the ratio of depth of water to width of the stream. Some of the above factors are, however, interdependent. Deposition will take place if the load becomes heavier which for the same type of material in suspension may result from a decrease of velocity or an entry of the stream into a shallow

and narrow region. If by means of any of these processes a nucleus is formed by deposition such that it offers resistance to the flow, further deposition results from the slowing down of the velocity of the water and continues either slowly or rapidly according to the prevailing conditions until the ' profile of equilibrium ' [Twenhofel, 1932] is reached. Under favourable circumstances, e.g. recession of the level of stream, sudden influx of materials and subsequent deposition, etc. the ' profile of equilibrium ' is overstepped and the deposited materials rise above the prevailing level of the stream, and thus a more or less stable and permanent land mass may be formed.

The deposited materials gradually get consolidated by their own weight and that of the standing water, colloidal material of the suspension forming structural aggregates. As the process of deposition continues, its rate becomes slower since the water level each time obtains a smaller head and when the land rises to a sufficient height there is little chance of deposition except during the tidal currents and floods. Most of the profiles of the Barisal and Bhola (Shahbazpur) soils show the deposit to be arranged in regular layers. They occur on the surface, or, a few inches below in recently formed *chars* or six to nine feet below the surface of old *chars*. The deposits consist of alternate layers of sand and silty clay,which together are generally about 2 mm. to 3 mm. thick. The clay layer can be peeled off. An ideal case where the actual manner of deposition may be somewhat quantitatively understood is visualized as follows :

The primary particles in an undisturbed suspension will settle down approximately according to their sizes which mainly determine the velocity of sedimentation. Sand will be deposited first, then silt and finally clay. As sand is being deposited, some finer particles may come down from the lower depths of the suspension. The sediment will, thus, assume a structure consisting of easily distinguishable layers of coarse and fine particles. It is possible, therefore, that the structure of the deposited material mentioned in the preceding page results from periods of low velocity or stagnant water during tidal floods. This ideal manner of deposition may be modified as a result of the salinity of the river water, tidal surges and other factors leading to fluctuations in the nature and content of the suspended matters. Salinity may have a coagulating effect on the finer particles and as a consequence, the aggregates will have a much larger settling velocity. The clay layer may thus be appreciably thick.

Parent material of the soils

Extensive examination of the soil profiles mentioned later shows that deposits consisting of the alternate layers of sand and silty clay constitute the parent material of the soils of Barisal and Shahbazpur which we have examined. It appears as the lowest horizon in the soil profiles and has obviously been acted upon by pedogenic processes leading to the development of the profile.

Procedure and methods

Location of pan layer

A survey of the depth and extent of occurrence of pan or hard layer has been made by inserting an auger at various points of a tract of land. This rough and ready method is useful but not accurate.

A compactometer prepared according to Keen and Cashen [1932] was used for measuring the hardness of the soil and its variation, if any, at different depths but did not prove very helpful. Porosity measurements with an air-pyknometer prepared according to Visser [1937] have been found to be of great help in locating the pan layer.

Collection of profile and field measurements

Vertical sections of the soil profile, i.e., the soil monoliths were collected according to the method of Polynov [1933]. The nomenclature of Stremme and Schlacht [1933] has been followed in describing the structure of the soil. It is difficult to judge the structure of moist soils and this has been noted in the profile descriptions. Colour has been recorded as visually observed in the field.

The presence of carbonates was tested in the field by pouring dilute hydrocholoric acid down the edge of the freshly dug profile. The effervescence may be roughly taken as a measure of the quantity of carbonate present and has been noted under the categories, ' no ' effervescence and 'weak ' or ' strong ' effervescence.

The presence of chlorides and sulphates was tested in the 1 : 5 clear KNO_3 extract of the soil. The content of available phosphorus of Barisal soils was determined colorimetrically using Truog and Meyer's method [Wright, 1939].

*p*H values of aqueous soil suspensions were determined by Kuhn's method using the Lovibond comparator [Wright, 1939]. The values thus obtained were compared in the laboratory with those obtained by the quinhydrone and glass electrodes. The results given in Table II show that the methods give values in good agreement. The *p*H of river and canal waters was also determined by the colorimetric procedure.

Table II

pH *values of aqueous suspension of soils by different methods using two laboratory samples*

Soil	Glass electrode	Quinhydrone electrode	Kuhn
Highland acid soil from Latekujan, Assam	5·4	5·3	5·0
Padegaon ' B ' type soil from Poona, Bombay	8·2	8·6	8·6

Laboratory analyses

The laboratory analyses of the soil samples could not be made locally and the samples had to be sent to Calcutta. The soils immediately after collection were wrapped in paraffin papers and packed in tinned cans with lids which were sealed with paraffin. The following analyses [Wright, 1939] were carried out: moisture content of the soil sample ; mechanical analyses by the International Soda method ; chemical analyses of the hydrochloric acid (25 per cent) extract of the soils involving estimation of Al_2O_3, SiO_2, Fe_2O_3, MgO, CaO, K_2O, Na_2O and P_2O_5 ; total analyses of the soils by fusion with Na_2CO_3 ; estimation of carbonate by Collin's calcimeter ; base exchange capacity and exchangeable bases (Mg, K and Na) by Schollenberger's method [Wright, 1939] and exchangeable Ca by Hissink-Tiulin method [Tiulin, 1927] ; analysis of soil solution comprising the estimation of CaO, MgO, K_2O, Na_2O, Cl', HCO_3', CO_3'', SO_4'' and total solids ; *p*H, and specific conductivity.

The soil solution was collected by the alcohol displacement method of Parker [1921]. The liquid was perfectly clear in most cases. There was, however, little or no displacement with moist clayey soils. With Barisal soils which are of a fine texture, the maximum recovery of soil solution did not exceed 50 per cent as judged from the moisture content, while with Bhola soils which have a coarser texture, it was generally about 80 per cent and not below 50 per cent excepting in two or three samples.

Soil series, types and phases

Table III shows the composition of the HCl extracts of the material of the C horizon from a few profiles. The composition is practically the same in all these places.

TABLE III

Composition of HCl extracts

Places	Profile number	Insoluble residue	Fe_2O_3	Al_2O_3	CaO	MgO	CO_2
Barisal	16	80·8	3·7	4·7	2·1	0·7	1·9
Patuakhali	78	79·4	5·3	7·2	0·65	1·6	..
Pirojpur	84	79·7	5·7	4·5	3·4	1·0	..
Char Shahib (Bhola)	9	82·0	4·4	4·6	1·8	1·7	1·1
	13	81·3	4·7	5·1	1·5	2·2	1·0

The profile features apparently vary in consequence of the differences in the pedogenic factors, cultivation and human interference, to which the parent material becomes subject.

The profiles of the old paddy lands show certain common characteristics and may tentatively be grouped under a single soil series, the Char Badna series consisting of the three textural types Char Banda clay, Char Banda loam and Char Badna sandy loam. These profiles show either distint pans or a compact layer (incipient pan).

The profiles of the older uncultivated lands under big trees, e.g., mango, guava, betelnut, coconut do not contain any pan or a compact layer. The profile features are not very distinctive but are easily differentiated from the Char Badna series. They are all loamy soils and may be named for convenience Sagardi loam.

The recent and old undisturbed *char* lands generally show the characteristic—alternate sand and silty clay layers almost from the surface downwards. The colour of the soil of older lands has altered from bluish grey, which is noticeable in the recent ones, to yellowish grey, mottled with reddish brown patches in between the layers. They may for convenience be designated as a separate series as the profile features are different from the others. They have been termed the Char Shahib series. There are two textural types, Char Shahib loam and Char Shahib sandy loam.

The soil profiles examined at Subarna Abad in the District of Khulna, have revealed that the area had been a swamp for sometime and a part of the decomposing plants, mostly reeds, has been covered by clayey material brought in by floods. It is difficult to put all of them into one definite category but in view of the existence of a horizon of decomposed plant material these soils have been tentatively designated as Subarna Abad peaty soils.

The soil series and types which have been distinguished are shown in Table IV which gives also the number of profiles examined, total area surveyed and the period of human habitation or age of the various *char* lands.

Char Badna series

The profiles representing the three types differentiated within this series have been shown in Table IV. Profiles 1, 2, 3 and 4 belonging to this series show certain difference from the rest. One typical profile from each type is described below :

Char Badna clay—Profile 84

Location. Village Kumuria, it is about one mile from the town Pirojpur and about 200 yards north of the Damodar channel.

Depth in cm.	Description
0 to 12	Clay loam ; grey in colour ; dry and hard ; falls to small clods when pressed ; grass roots ; no effervescence.
**12 to 44	Clayey ; darker in colour than above ; compact and hard ; prismatic structure ; no effervescence.
44 to 83	Clay loam ; brownish grey in colour ; moist on effervescence.
83 to 134	Blue coloured alternate layers of sand and silty clay ; very moist ; insect bores and brown incrustations ; no effervescence.

** Pan horizon

TABLE IV

Soil series and types

Soil series	Soil types	Profile numbers	Subdivision	Total area surveyed in acres	Number of profiles examined	Period of human habitation or age in the case of new *chars* in years	Localities
Char Badna	Clay	69 to 79	Patuakhali	325	11	150	Patuakhali, Lohallya
		80 to 91	Pirojpur	255	12	150 to 200	Pirojpur, Kumuria, Muktarkati, Shikarpur, Machinpur
	Loam	1 to 8, 15 to 18, 22, 24 to 27, 29 to 32, 33, 36 to 42, 56 to 68, 92 to 99, 108 to 111	Barisal	1020	54	100 to 200	Sagardi, Char Badna, Rupatali, Char Badna Char Aicha, Pakshirchar Lakhutia, Jagua, Raipura, Taltali, Madhabpasha
		112 to 117	Patuakhali Galachipa	225	6	100 to 150	Galachipa bandar, Ratnadi
	Sandy Loam	48 to 55	Bhola	180	8	150 to 200	Kalupura, Gazaipur
Sagardi	Loam	23, 28, 34, 35	Barisal	20	4	100 to 150	Sagardi, Rupatali, Char Banda, Char Kaua
Char Shahib	Loam	19 to 20, 43 to 47, 59	Barisal	10 30 40	2 5 ..	3 to 40 200 40 to 50	Char Monai, Char Karnakat, Kashipur, Kalasgram, Bakshirchar
		118 to 121	Patuakhali Galachipa	230	6	50 to 75	Krishnapur, Dauka, Badarpur, Haridevpur
	Sandy Loam	9 to 14, 21	Bhola	80 5	6 1	8 to 40 60 to 70	Char Shahib, Char Said, Char Rames, Char Bhadoria, Char Jangalia
Subarna Abad	Peat	100 to 107	Khulna	600 to 1000	8	20 to 22	Subarna Abad

Char Badna loam—Profile 8

Location. Situated about two miles south-east of Char Kaua and about 100 yards off from the Barisal river.

Vegetation. *Croton parsiflora* in certain places and short grass *Cardaenthera triflora* Ham., locally known as *Kala* was found to grow luxuriantly in some of the plots of land. The weed is said to grow well under water-logged conditions and in paddy fields.

Depth in cm.	Description
0 to 10 . .	. Moist ; slightly dark ; loam ; grass roots ; structureless and falls to powder when pressed ; strong effervescence ; *p*H 7·1.
10 to 48 . .	. Drier and more compact than above ; grey in colour ; grass roots ; crumbles easily into grains under pressure of fingers ; granular structure ; strong effervescence ; *p*H 7·1.
**48 to 96 . .	. Dry ; blackish brown ; compact ; clayey and soapy to the touch on wetting ; easily splits into prisms, some of which are quite large and show many sharp edges and angles ; weak effervescence ; a well defined clay pan ; *p*H 7·0.
96 to 140 .	. Very moist, yellowish with intermingled brownish red patches ; clayey and sticky dried up into hard blocks ; weak effervescence ; *p*H 7·0.
140 and below .	. Very moist : pure glistening sand with layers of silty clay between ; weak effervescence ; *p*H 7·1.

Char Badna sandy loam—Profile 50

Location. Village Kalupura, the site is about half a mile east of Kalupura steamer station and 250 yards south of the District Board road.

Vegetation. *Motha* and grass.

Depth in cm.	Description
0 to 8 . .	. Sandy loam ; moist ; dark coloured ; brown incrustations ; grass roots ; structureless ; no effervescence.
*8 to 43 . .	. Clay loam ; compact and hard weakly developed prismatic structure ; insect bores and brown incrustations, no effervescence.
43 to 57 . .	. Loam ; moist and soft ; transition layer between the upper and the lower layers ; no effervescence.
57 to 107 .	. Parent material but more sandy than observed in Barisal soils ; no effervescense.

* Incipient pan horizon.

As already stated, the characteristic feature of the profiles of this series is the occurrence of an impervious and compact horizon or pan below the surface. This is most particularly noticeable in the case of the Char Badna loam and the Char Badna clay. In Char Badna sandy loam the pan is no doubt present but because of the coarser texture of the soils it is neither as hard and compact nor is the structure of the soil so markedly prismatic as in the case of the other two types.

The soils of the pan horizon, particularly of the clay and the loam types, differ from the other horizons of the profile in both physical and chemical properties. The total pore space has generally a lower value in the pan horizon (Profile 8 : 0 to 10 cm., 52·0 ; 10 to 48 cm., 33·1 ; 48 to 96 cm., 22·9 ; 96 to 140 cm., 31·0).

The soils of the pan horizon have characteristically a prismatic structure whereas those of layers above and below are either structureless or have sometimes a granular or angular structure. The pan horizon is dark in colour in contrast to the light grey or yellow colour of the layers above and below it. From the mechanical analysis of profile samples (Table V) it appears that the content of clay as also the clay and silt increase downwards to a pronounced maximum at the pan horizon.

In the case of Char Badna loam, where parent material contains $CaC0_3$, the percentage of $CaC0_3$ shows a minimum in the pan horizon of the profile. The other types which contain very little $CaC0_3$ do not show such variations. The results of chemical analyses (Table VI) show certain interesting features. The analyses of the loam types show that the percentage of HCl soluble Al_20_3 has the highest value in the pan horizon ; otherwise, there is apparently not much variation in the various layers.

The percentage of Ca0 and also the Ca0 : Mg0 ratio show minimum values in the pan horizon especially of the loam type.

The base exchange capacities and exchangeable bases of some of the profile samples of the Char Badna loam have been determined and the values are shown in Table VII. In this soil type in which a pan horizon has been found to be present, the base exchange capacity generally shows a maximum value in an intermediate layer coinciding more or less with the pan horizon itself. This is in accord with the fact that this horizon also contains the highest amount of clay. The amount of calcium which constitutes the major proportion of the exchangeable bases is also the highest in the pan layer due evidently to the same factor, i.e. the highest clay content. Other aspects of the base exchange measurements are discussed later (p. 23).

Char Badna—eroded phase

It has been noticed that the texture, structure and other properties of the surface soils of profiles 16 and 17 agree more or less with the soils of the pan horizon of the corresponding profiles 5 and 8. It is possible, therefore, that due to the eroding effect of flood waters the A-horizons of profiles 16 and 17 have been washed off leaving bare the pan horizon at the surface. Profiles 16 and 17 are, therefore, to be considered the eroded phases in the Char Badna loam.

TABLE V

Mechanical analysis of soils

Profile number	Depth in cm.	Moisture per cent	Loss on ignition per cent	Coarse sand per cent	Fine sand per cent	Silt per cent	Clay per cent	Loss on solution per cent	Clay and silt per cent	$CaCO_3$ per cent
8	0 to 10	1·5	3·1	0·2	32·6	46·4	12·2	1·4	58·6	4·1
	10 to 48	1·8	2·0	0·6	25·2	46·7	17·9	1·0	64·6	6·0
	**48 to 96	4·5	5·7	0·3	3·2	42·5	46·2	1·0	88·7	2·0
	**96 to 140	3·9	5·2	0·03	4·3	46·0	40·8	1·8	86·8	3·1
	140 to	0·7	3·7	2·8	73·8	7·8	8·1	1·2	15·9	3·3
12	0 to 40	0·6	3·9	0·7	61·7	24·2	7·0	0·9	31·2	2·2
	40 to 80	1·1	2·9	*nil*	57·2	28·1	7·6	1·0	35·6	2·2
	80 to 102	1·0	2·8	..	52·4	31·6	10·3	2·8	41·9	1·6
	102 to 120	1·5	3·2	..	29·6	46·3	16·1	2·7	62·4	2·1
19	0 to 22	0·2	3·4	..	48·4	36·5	9·8	2·0	46·3	1·0
	22 to 100	0·5	2·6	..	42·1	..	..	1·4	48·9	4·0
	100 to 140	0·3	2·4	..	63·1	2·7	27·3	1·7	30·0	3·5
	140 to 190	0·2	1·4	..	85·7	5·2	4·6	1·8	9·8	2·0
84	0 to 12	3·9	7·2	*nil*	4·6	48·8	29·2	2·9	78·0	..
	**12 to 44	6·2	6·7	*nil*	2·1	25·6	65·4	2·8	91·0	..
	44 to 83	3·6	6·7	*nil*	2·8	52·9	34·8	4·2	87·7	..
	83 to 134	2·4	4·8	*nil*	31·3	35·45	22·75	2·6	58·2	..
100	0 to 15	10·6	46·85	*nil*	3·6	11·7	39·1	7·2	50·8	..
	15 to 28	9·[illegible]2	47·5 20·1	*nil*	0·2	4·0	80·5	2·9	84·5	..

** pan horizon

TABLE VI

Chemical analysis of the HCl extracts

Profile number	Depth in cm.	Insoluble residue per cent	Soluble SiO_2 per cent	R_2O_3 per cent	Al_2O_3 per cent	Fe_2O_3 per cent	CaO per cent	per cent	K_2O per cent	Na_2O per cent	P_2O_5 per cent
8	0 to 10	79·7	..	..	5·9	..	2·7	1·3	..	..	..
	10 to 48	78·0	..	..	7·5	..	2·6	1·3	..	..	..
	48 to 96	69·7	..	..	13·5	..	1·0	1·3	..	..	..
	96 to 140	68·6	..	..	11·2	..	2·0	1·2	..	..	..
	140 to down	85·5	..	..	4·9	..	2·3	0·8	..	..	..
19	0 to 22	82·4	·12	..	4·7	3·2	2·6	1·6	·25	·11	·10
	22 to 100	77·0	·12	..	7·8	2·6	5·9	1·8	·29	·10	·11
	100 to 140	83·2	·20	..	3·9	3·1	4·5	1·1	·18	·11	·13
	140 to 190	87·0	·15	..	3·5	2·9	4·2	1·2	·10	·10	..
50	0 to 8	80·98	·23	13·6	11·1	2·5	·8	·6	·2	·7	·01
	8 to 43	78·3	·30	10·1	7·8	3·3	1·1	·8	·1	·4	·01
	43 to 57	78·8	·30	11·3	8·9	2·4	·7	1·3	·3	·3	·01
84	0 to 12	75·0	·24	15·1	12·3	2·8	·99	1·1	..	..	..
	12 to 44	74·4	·20	17·74	15·0	2·7	1·03	·29	..	..	..
	44 to 83	80·28	·7	17·2	10·43	6·47	·6	1·42	·54	·23	·30
	83 to 134	79·7	·77	10·5	4·5	5·72	3·4	1·02	·43	·25	·28
100	0 to 15	57·52	·40	9·43	..	2·1	1·76	1·12	·96	·91	·08
	0 to 15	55·34	·40	9·33	..	2·2	1·16	0·31	·90	·87	·08
	15 to 28	56·2	·41	19·83	..	2·5	1·48	1·36	·88	·87	·1

Sagardi series

Description of a typical profile of the only type identified in this series is given below :

Sagardi loam—Profile 35

Location. Char Kaua, about 1½ miles south-east of Char Badna Agricultural Farm, the orchard belongs to Abdul Karim, Howladar.

Vegetation. Arecanut, *madar*, *jamrul*, mango and such other trees.

Depth in cm.	Description.
0 to 16	Loam ; dark in colour due to humus matter ; plant roots ; slightly moist ; friable structure ; strong efferversence with HCl ; *p*H 7·4.
16 to 60	Same as above except that the colour is lighter ; *p*H 7·2.
60 to 120	Loam ; irregular deposits of sand in layers resembling the ' deposit horizon ' ; no brown incrustations, strong effervescence with HCl ; *p*H 7·4.
120 to 200	Clay loam ; moist ; breaks up into lumps when pressed; irregular deposits of sand as above ; strong effervescence with HCl ; *p*H 7·4.

No analyses of the soil samples belonging to the series have been made.

Char Shahib series

One profile of each of the two types in this series is described below :

Char Shahib loam—Profile 19

Depth in cm.	Description
0 to 22	Moist ; dark grey ; loam ; grass roots in plenty ; yellowish tinge scattered everywhere ; crumbs fall into powder under pressure of fingures, slightly hard and shows somewhat angular structure ; weak effervescence ; *p*H 7·4.
22 to 100	Grey deposition horizon ; plenty of brown incrustation between two layers ; insect bores in abundance, having coatings of brown iron oxide round them ; strong effervescence ; *p*H 7·3.
100 to 140	Moist ; Sandy ; parent material ; brown patches between two layers ; blue coloured soil material is found to be mixed in the lower portion of the horizon ; no plant roots and insect bores ; strong effervescence ; *p*H 7·5.

Depth in cm.	Description
140 to 190	Very moist ; blue coloured parent material having a maximum thickness of about 6 mm. no plant roots ; insect bores not plenty ; near the water level ; strong effervescence ; *p*H 7·5.

Char Shahib sandy loam—Profile 12

Depth in cm.	Description
0 to 40	Yellowish grey fine sand deposited in layers alternating with a thin layer of relatively coarser sand particles ; grass roots, very weak effervescence *p*H 7·2.
40 to 80	Greyish fine sand and silt arranged in layers containing thin patches of iron oxide between them ; very weak effervescence ; *p*H 7·2.
80 to 102	Deposits of yellowish grey fine sand and dark blue silt occur in layers distributed in a non-uniform manner ; widely scattered patches of iron oxide ; very weak effervescence ; *p*H 7·2.
102 to 120	Dark blue sandy loam ; patches of iron oxide ; very weak effervescence ; *p*H 7·2.

True soil horizons cannot be readily distinguished in most of the profiles. The structure is undeveloped. A differentiation into horizons is, however, possible by means of colour and texture. Most of the layers maintain their original undisturbed deposits intact. The surface soil sometimes lacks the usual layer feature due either to short-time cultivation or grazing, etc. The study of the profiles is interesting in so far as it gives important information about the changes subsequent to the formation of the *chars* which are responsible for the development of the pan.

The sandy loam type occurs in Bhola where the soil contains large amount of salts, such as NaCl and $CaCl_2$.

The mechanical and chemical composition of the soils of the two types are somewhat different but those from the different layers of the same profile do not show much variation (Tables V and VI). The base exchange capacities are low (Table VIII) and do not show any variations along the profile. Other aspects of base exchange measurements are discussed later (p. 23).

Nature of the observed pan and its formation

Of the several types of pan described in the literature, the most important ones are (*a*) ortstein or iron-humus-clay pan ; (*b*) plough pan and (*c*) clay pan. A clay pan has been defined as ' horizon of accumulation of stiff impervious clay '. The pan observed by us meets this description. Brown, Rice and Byers [1933] from a study of the clay pan profiles of Nebraska, Montana and Minnesota came to the conclusion that they were produced by translocation of colloids as a whole from the

surface downwards by dispersion and cultivation. Soluble salts especially $Ca(HCO_3)_2$ formed from $CaCO_3$ bearing rocks flocculate the dispersed colloid tending to form a stiff impervious layer. For the formation of clay pans in humid regions Jenny and Smith [1935] have assumed that as the rain water percolates through the soil it carries the colloidal material in a dispersed condition. The accumulation results from coagulation in presence of $CaCO_3$ or by mechanical sieving. Formation of clay *in situ* [Norton and Smith, 1929; Bray, 1935; Nikiforoff and Drosdoff, 1943] and deflocculation of clay at lower *p*H at the surface followed by eluviation to a lower zone of higher *p*H [Russel and Engle, 1925] have also been assured.

In the present survey it has been observed that pans are present only in older cultivated *chars*; and the older the char, the more well defined is the pan. No pan or even a hard layer occurs in the profile of (1) Sagardi series which are old but uncultivated and are under deep rooting crops and (2) Char Shahib loams and sandy loams which are quite young. It appears, therefore, that the agricultural parctices in the region have some bearing on the formation of the pan. The usual practice by the farmers of reclaiming a recently raised *char* is to plough it and plant paddy crops in a small plot. Ploughing and subsequent action of rains and flood help to leach out salts which concentrate on the surface as a result of capillary rise and evaporation, whereas paddy seems to act as an indicator plant. As soon as paddy has a good growth, the farmers begin to sow it regularly. When cultivation becomes possible on the *chars*, the deposits are subjected to a variety of more systematic disturbing influence in the form of cultivation, grazing, cropping, etc. Some of these cause a puddling effect which aided by rain and flood water makes a suspension of the deposits. As this suspension settles, the coarser particles come down first and afterwards the clay and silt. The relatively coarser sandy bed allows the finer materials to pass through, the process being facilitated through the agency of the downward percolating water. The finer particles gradually fill up the interstices till the porosity is so reduced that percolation of water downward becomes difficult and ultimately impossible, when the process has gone on for a long time. Accumulation of clay goes on higher up and a well defined clay pan is originated.

Subarna Abad peaty soils

Auger examination of the soils shows that the upper few feet of the low lands contain mainly undecomposed and decomposed parts of reeds and plants including humus matter. These are black in colour, very light and of offensive odour. In the comparatively high lands a soil cap of about two to four feet in depth is present. Below this depth, however, remnants of plants in various stages of decomposition and humification are present. Profiles up to a depth of six feet were examined in areas which bear good crops and which do not. It was difficult to dig deeper pits because of the seepage of water. A description of one profile lying in the lower areas of the tract is given below:

Subarna Abad peaty soil—Profile 100

Locality. Quarter mile east of the landlord's office and 200 yards north of the 'Puntimari river'.

Age. About 200 years.

Topography. Slightly undulating. Pit dug in the depression between the landlord's office and the bund to the east of it.

Drainage. Impeded ; swampy in the rains ; gets water-logged from June to January.

Vegetation. Shamla grass and reeds.

Human influence. Cultivation for about 20 to 22 years after elimination of *nal-khagra* reeds.

Depth in cm.	Description
0 to 15	Black coloured, loose ; decomposed parts of plants and reeds ; light ; hard on drying ; grass roots in plenty ; no effervescence with HCl ; *p*H 5·4 ; Cl′ present ; SO_4'' present.
15 to 28	Clay ; brownish grey in colour ; moist ; very sticky ; no plant remains ; no effervescence in general ; in places however there are dead conches which give effervescence with HCl ; *p*H 5·4 ; Cl′ present ; SO_4'' present.
28 to 93	Decomposed parts of reeds and plants ; dark in colour no effervescence ; *p*H 5·6 ; Cl′ present ; SO_4'' present.
93 to 131	Light grey coloured clay ; very moist and sticky ; no effervescence ; Cl′ present ; SO_4'' present.
131 to down	Decomposed parts of plants and reeds mixed with undecomposed remains ; brown coloured ; very loose ; no effervescence ; Cl′ present ; SO_4'' present.

The indications are that the area had been a swamp for sometime and part of the decomposing plants, mostly reeds, has been covered by the materials laid down by floods. These are highly clayey and contain large amounts of humus matter, as will be seen from the figures given in Tables V and VI. The results of determination of the base exchange capacity and the lime requirement of the soil samples are shown in Table IX. The high b.e.c.'s are perhaps largely due to the inorganic clay fraction which is also very high and varies from 59·1 to 64·4 per cent. The organic matter appears to be present in an undecomposed state and contributes little to the base exchange capacity. The soils are acidic and the lime requirement measured by the method of Hardy and Lewis [Wright, 1939] varies from 0·23 to 0·61 per cent CaO. In actual liming practice, however, a larger amount would be necessary to help decomposition of the large quantities of undecomposed plant residues.

TABLE VII

Base exchange capacity and exchangeable bases

Profile	Depth in cm.	(Exchangeable bases) Ca	Mg	K	Na	Total	B.e.c.
No. 1	0 to 7	12·46	3·88	·082	·016	16·44	16·77
	7 to 9	17·54	2·60	·094	·014	20·20	16·94
	9 to 24	13·82	4·52	·047	·010	18·40	18·95
	24 to 36	16·97	2·74	·053	·008	19·77	20·53
	36 to 120	12·65	2·47	·036	·010	15·18	17·10
No. 2	0 to 14	14·96	5·80	·025	·010	20·80	21·67
	14 to 24	16·18	5·85	·025	tr.	22·06	23·05
	24 to 46	16·00	5·58	·031	·009	21·62	21·86
	46 to 83	14·67	5·65	·040	·008	20·37	21·67
	83 to 120	15·47	3·53	·035	·009	19·04	19·88
No. 3	0 to 8	12·39	1·80	·056	..	14·25	13·45
	8 to 38	10·53	3·2	·090	·009	13·83	12·75
	38 to 59	11·73	2·8	·030	..	14·56	14·46
	59 to 76	12·1	2·2	·074	..	14·37	13·85
	76 to 105	14·92	2·9	·080	..	17·90	18·2
	105 to 123	18·14	3·1	·056	..	21·30	21·6
No. 6	0 to 14	4·00	1·9	..	·008	5·9	5·1
	14 to 25	8·73	2·37	·06	traces	11·67	11·1
	25 to 50	12·00	1·9	·045	..	13·95	13·25
	50 to 79	14·91	2·8	·11	..	17·82	19·2
	79 to 94	15·00	3·0	·095	..	18·10	18·8
	94 to 180	12·1	2·15	·031	..	14·28	15·1
No. 7	0 to 13	3·90	1·09	·024	trace	5·01	5·8
	13 to 30	4·70	trace	·05	*nil*	4·75	5·2
	30 to 69	6·25	·55	·04	·003	6·84	7·3
	61 to 118	6·80	1·1	·010	traces	7·96	8·1
	118 to 140	7·35	1·1	·015	..	8·47	9·0
No. 8	0 to 10	7·0	3·3	·070	..	10·37	11·9
	10 to 48	14·6	3·2	·043	..	17·84	19·0
	48 to 96	32·3	3·8	·096	..	36·20	35·8
	96 to 140	19·24	3·2	·040	..	22·48	22·65
	140 down	3·4	trace	..	..	3·4	4·25

Table VIII

Base exchange capacity and exchangeable bases

Profile number	Depth in cm.	M.e. of bases in the NH_4Ac extract				M.e. of bases in soil solution				M.e. of exchangeable bases				Sum (S)	B.e.o. (T)
		Ca	Mg	Na	K	Ca	Mg	Na	K	Ca	Mg	Na	K		
9	0 to 10	4·4	2·2	2·3	..	1·5	0·3	2·0	0·9	2·9	1·9	1·3	..	5·1	2·9
	10 to 20	5·4	1·9	11·1	..	5·6	0·3	9·6	tr.	..	1·6	1·5	..	3·1	2·9
	55 to 99	5·3	0·7	1·9	..	2·7	0·2	2·0	0·1	2·6	0·5	..	..	3·1	3·7
	90 to 130	4·2	0·8	2·6	0·1	1·5	0·1	2·3	tr.	2·7	0·7	0·3	0·1	3·8	3·2
10	0 to 6	5·6	0·9	4·5	0·1	3·4	0·7	3·9	tr.	2·2	0·2	0·6	0·1	3·1	2·8
	8 to 16	4·2	0·7	6·1	tr.	2·5	0·9	5·2	tr.	1·7	..	0·9	..	2·6	2·9
	16 to 27	8·9	3·9	6·8	tr.	6·5	3·3	5·3	tr.	2·4	0·6	1·5	..	4·5	3·1
	27 to 50	2·3	0·3	0·9	0·4	0·3	tr.	1·0	tr.	2·0	0·3	0·8	0·4	3·5	2·9
	50 to 59	3·8	0·9	1·2	0·1	1·2	0·3	n.d.	n.d.	2·6	0·6	1·2	0·1	3·2	2·7
11	0 to 10	5·0	1·9	7·8	..	3·9	1·7	10·9	..	1·1	0·2	..	..	1·3	3·6
	10 to 25	5·3	0·9	2·8	..	1·5	0·4	3·9	..	3·8	0·5	..	..	4·3	3·6
	25 to 41	2·2	0·9	2·1	0·3	0·6	0·1	1·7	..	1·6	0·8	0·4	0·3	3·1	3·2
	41 to 60	2·8	1·0	1·5	0·4	1·0	0·2	1·4	0·1	1·8	0·8	0·1	0·3	3·0	3·5
12	0 to 40	4·5	0·8	10·1	..	16·5	1·4	13·4	tr.	..	..	..	..	..	2·0
	40 to 80	5·3	0·9	8·6	..	7·8	0·8	7·8	..	..	..	..	..	..	2·8
	80 to 102	6·8	1·6	7·2	..	8·2	1·8	6·8	tr.	..	..	..	..	..	2·5
13	0 to 12	3·7	tr.	2·6	..	0·6	0·5	2·5	tr.	3·1	..	0·1	..	3·2	3·2
	12 to 48	4·6	0·9	5·2	..	1·2	1·0	4·3	tr.	3·4	..	0·9	0·3	4·6	4·1
	48 to 66	2·3	0·3	3·2	tr.	0·3	0·3	1·9	tr.	2·0	..	1·3	..	3·3	2·8
	66 to 82	4·2	0·4	3·0	0·3	..	..	..	..	..	..	..	..	..	3·6
14	0 to 36	6·6	tr.	1·8	..	0·5	0·3	1·1	tr.	6·1	..	0·7	..	6·8	6·5
	36 to 52	4·8	1·1	8·4	tr.	0·9	0·9	6·5	tr.	3·9	0·2	1·9	..	6·0	5·4
	52 to 80	3·8	0·5	4·2	0·3	..	..	..	..	..	..	..	..	..	4·1
	80 to 123	3·1	1·0	2·9	tr.	..	..	..	..	..	..	..	..	..	2·6

TABLE IX

Base exchange, capacity and lime requirement of the soil

Profile	Depth in cm.	B.e.c. in m.e. per 100 gm. soil	Lime requirement in gm. of CaO per 100 gm. soil
100	0 to 15	48·1	0·61
	15 to 28	33·8	0·23

AGRONOMIC ASPECTS OF THE PRESENT SURVEY ; SALINITY ; SOIL SOLUTION ; EXCHANGEABLE BASES ; PLANT NUTRIENTS

In course of this work a large amount of data has accumulated regarding the soils of this coastal region, which besides having a bearing on the problem of pan formation, are of agronomic value. The deficiency of S and of P requires attention. It is, however, true that continuous deposits of river-borne materials in many places make up much of the deficiency. The large quantities of salt in soils of the southern and eastern part of the district (e.g. in Bhola) give rise to an adverse state of the soil. The reaction of the soils, presence of $CaCO_3$ and the high content of exchangeable Ca are favourable factors.

With regard to the coastal soils the study of the soil solution is of great importance, because the soil is usually impregnated with salts from the rivers and the sea. It will be seen from the results given in Tables X and XI that the concentration of salts in the soils of Barisal is not large and the major constituent is calcium bicarbonate. The river, canal and waters from pits dug for profiles 1 and 2 also contain calcium bicarbonate as the major constituent ; but its concentration in the soil solution is, as it should be, greater than in the latter. The main constituent of the soil solution of soils from Bhola are NaCl and $CaCl_2$ which are also the major constituents of the river and canal waters of the localities.

The concentration of the salts is sufficient to be detrimental to crop growth. In the latter part of the winter and during the summer season, before the rains set in, there is an accumulation of salt in the upper layers. Such accumulation should be more prominent in the Bhola Chars on account of the higher salinity of the surrounding waters. The *p*H values of the soil solutions were found to be more or less of the same as determined in the field by Kuhn's method.

The results for base exchange capacity and exchangeable bases of a few are given in Tables VII and VIII. The variation of base exchange capacity of the soils of the different horizons of a particular profile is similar to the variation of the clay content of the soils.

TABLE X

Analysis of soil solution

(Expressed as p. p. m. of solution)

Soil profile	Depth in cm.	Total solids	CO_3=	HCO_3=	Cl—	SO_4=	CaO	MgO	K_2O	Na_2O	*p*H
No. 1	7 to 9	440	*nil*	274	25	*nil*	136	42	..	..	7·2
	9 to 24	420	*nil*	172	66	*nil*	176	45	..	..	7·3
	36 to 120	240	*nil*	184	36	*nil*	99	20	..	..	7·2
No. 2	24 to 46	400	*nil*	133	62	*nil*	82	22	..	..	6·9
	46 to 83	340	*nil*	141	52	*nil*	41	57	..	..	7·1
	83 to 120	..	*nil*	..	..	*nil*	91	33	..	..	6·9
No. 6	0 to 14	292	*nil*	156	36	..	66	44	5	..	8·2
	25 to 50	2190	*nil*	169	1088	..	458	172	60	..	7·8
	79 to 94	2650	*nil*	120	838	..	264	..	..	..	8·2
	94 to 120	850	*nil*	120	658	..	198	..	..	..	8·1
No. 7	15 to 30	1064	..	433	213	..	190	79	30	..	8·2
	30 to 61	916	..	444	46	..	180	46	48	..	7·9
	61 to 118	240	..	192	36	..	77	29	..	..	8·2
No. 8	0 to 10	576	..	337	40	..	95	46	60	..	7·8
No. 10	0 to 8	13570	..	75	6095	*nil*	2477	321	tr.	3250	7·4
	8 to 16	10000	..	216	4712	*nil*	1244	252	39	2996	8·8
	16 to 27	16688	..	84	9764	*nil*	4312	1326	57	4073	5·6
	27 to 50	1670	..	390	724	*nil*	162	30	84	617	8·4
	50 to 59	3432	..	308	..	*nil*	741	104	..	..	..
No. 12	0 to 40	6632	..	102	3202	..	419	220	tr.	2052	7·1
	40 to 80	14724	..	119	7011	..	997	475	34	3953	7·8
	80 to 102	3440	..	212	1708	..	159	116	37	1322	..
	102 to 120	..	..	..	..	..	..	..	..	..	..
No. 14	0 to 36	22220	..	108	12720	..	2830	720	tr.	9040	7·6
	36 to 52	5985	..	108	3454	..	1030	148	84	2438	7·1
	52 to 80	3337	..	173	1782	..	426	60	75	1410	7·0
	80 to 123	451	..	86	2153	..	838	85	141	1510	7·0

TABLE XI

Analysis of canal, river and pit waters

(Expressed as p. p. m. of water)

—	Total solid	CO_3=	HCO_3—	Cl—	SO_4—	CaO	MgO	K_2O	Na_2O	*p*H
Sagardi No. 1 pit water	710	*nil*	590	13	*nil*	158	*nil*	..	..	7·6
Sagardi No. 2 pit water	350	*nil*	230	15	*nil*	85	*nil*	..	..	8·2
Sagardi canal water	270	*nil*	157	9	*nil*	48	*nil*	..	..	8·0
Barisal river water	300	*nil*	142	5	*nil*	43	*nil*	..	..	8·0
Bukhainagar river water	175	*nil*	133	5	*nil*	30	*nil*	..	..	8·0
Char Kaua canal water	257	*nil*	116	10	*nil*	38	16	25	tr	8·6
Rupatali canal water	162	*nil*	79	6	*nil*	21	17	21	4	8·1

The base exchange capacity is, as already mentioned, maximum in the case of the soils of the pan horizons, which contain the highest amount of clay. The S and T values are almost equal showing the soils are base saturated. This is expected from the high *p*H values and the presence of free $CaC0_3$ in the soil. Of all the exchangeable bases Ca is the major constituent. Mg comes next. The amount of exchangeable K is very low and Na is present only in traces except in the Bhola soils. Exchangeable Ca has a maximum value in the pan horizon which shows that although $CaC0_3$ content is very low or negligible in the pan horizon, the clay is more than 80 per cent saturated with Ca. Bhola soils contain large amounts of water soluble salts. The difficulties of estimating exchangeable bases in saline soils are well known. Approximate correction has been applied by subtracting the content of individual bases present in the soil solution from the corresponding bases in the salt extracts used for estimating the exchangeable bases. The amounts of exchangeable bases calculated in this manner show that excepting a few instances T and S values do not differ much between themselves. As free calcium carbonate and soluble salts including calcium bicarbonate are present, the agreement between T and S may be taken to suggest that the basis of calculation made above and the assumption that the soil solution contained only free salts present in solution in the soil are possibly not very incorrect. Calcium constitutes the major proportion of exchangeable bases. The soils of Bhola have very low base exchange capacity, which more or less correspond to the low clay content.

Ameliorative measures

Of the possible ameliorative measures, chemical treatment, planting of deep rooting crops, and administrative control of agricultural practices suggest themselves.

Various chemicals such as lime, lime carbonate, gypsum, superphosphate containing calcium as the predominant ion were applied to the pan soils in the field to see if the flocculating action of calcium ion can improve the structure of the soils of the pan horizon. No conclusive evidence has been obtained.

Pan is absent under deep rooted trees. Trees such as arecanut or coconut which grow well in the tracts and are of great economic value may be planted for several years to break the pans.

The cultural methods practised by farmers contribute much to the factors responsible for pan formation. In new *chars* it is necessary to control the cultural practices employed by farmers to reclaim them. The farmers should know simple method of irrigation to wash out the salts and the evil effects of disturbing the deposits as they do it, when the land is still young and a victim to frequent submergence.

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STUDIES IN THE CHEMISTRY OF SUGARCANE JUICE IN RELATION TO CLARIBILITY IN *GUR* MANUFACTURE

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(Received for publication on 7th June, 1948)

It is common experience in *gur* manufacturers' practice to find large variations in the quality of *gur* resulting from different varieties of cane, even when prepared under identical conditions—the colour of the product ranging from golden yellow to dark chocolate, texture from highly crystalline to amorphous and taste from fine to disagreeable. It is thus clear that the claribility of juices (i.e., the extent to which they are amenable to clarification) is subject to a great deal of variation obviously not depending on differences in sucrose content, as is seen from the fact that even when the sucrose contents of two juices are of the same order, the end products very often stand in sharp contrast with respect to quality. It is well known that non-sugar juice constituents, mostly colloidal in nature (gums, pectin, protein, etc.) are responsible for serious milling difficulties in white sugar manufacture and that mineral matter and phosphate contents of juices also play an important part. Varietal differences in respect of these ingredients have also been observed by several workers [Ramanaya and Vishwanath, 1935 ; Ramanaya, 1936 : Ramanaya and Satyanarayana, 1938]. Considering that in spite of the very effective methods for the elimination of colloidal matter inherent in the vacuum pan process, these substances give rise to considerable difficulties in manufacture, their very harmful effect in the open pan system of manufacture where such methods of elimination are not available, need hardly be emphasised. In selecting cane varieties suitable for the open pan industry, it is, therefore, of the greatest importance to pick out such varieties as would provide juices of the highest degree of claribility and in this connection a study of the chemical criteria of juices in relation to claribility is of great interest. These investigations [Khanna 1945, 1946] were, therefore, undertaken with the object of ascertaining the chemical attributes associated with different degrees of claribility with respect to a number of important varieties, so as to ultimately arrive at the optimum characteristics required of varieties to be crushed for open pan boiling.

Experimental

The experimental work consists in observations over three successive seasons of which the first two seasons' investigations were of an exploratory nature, underaken with the object of ascertaining general trends, if any. The data pertaining to the third season, on the other hand, were collected on a strictly statistical basis and under rigidly controlled experimental conditions and only these data form the basis of correlation coefficients worked out at a later stage. In other words, the first two

years' studies should be regarded as pointing to general trends of behaviour which were under detailed examination in the third season, when appropriate analyses of variance were performed and correlation coefficients worked out. The varieties used in the first season were Cos. 313, 383, 395, 453, 513 and B.Os. 3, 9, 10, 11, 21 and *gur* was prepared from them under identical conditions, clarification of juice being done by the commonly used preparation—*bhindi* mucilage (the mucilaginous extract of the green stems of *bhindi-Hibiscus esculentus*). The products were examined in detail and classified with respect to quality on the basis of their general features such as hardness, texture, taste and colour, as well as important quantitative physical and chemical criteria—sucrose, glucose, moisture, acidity, pore space, intensity of colour of standard solutions and amount of insoluble impurities, measured as 'turbidity' of standard solutions. In the third season's experiments, ash contents were also determined and nett rendements (=sucrose per cent—glucose per cent—3·5× ash per cent) calculated. An identical procedure was adopted in the second year, the varieties examined being Co. 313, Co. 383, Co. 395, Co. 453, Co. 508, Co. 513, B.O.3, B.O.10, B.O.11, B.O.15, B.O.21 and B.O.24. Most of these are from the previous year's list, the rest being new introductions. The juices of all the varieties were also analysed for sucrose, glucose, total colloidal matter, gums, pectin, crude protein, ash and phosphate. In the third season, the experiments were conducted on a statistical basis with reference to four varieties (Co. 313, Co. 513, Co. 453 and Co. 383) in four replications, using three juice treatments (*bhindi* mucilage, castor seed extract and groundnut extract) in each case. The conditions of boiling were very carefully standardized each pan being struck at the same temperature (118°C.) recorded with precision. Statistical analysis of data so collected may, thus, be expected to lead to a satisfactory correlation of *gur* quality with juice characteristics.

The analytical methods for most of these determinations have been described in a previous communication [Khanna and Chacravarti, 1949], those for the others being briefly stated below :

Total colloidal matter

Determined as follows by the method of Kharin and Smirnova [1936]. The juice is diluted to 10° Brix and allowed to settle. To 5 c.c. of the supernatant liquid, 45 c.c. of rectified spirit and 5 c.c. ether are added, the liquid boiled for three to four minutes on an electric stove and allowed to settle. The precipitate is taken on a tarred filter paper, washed with 100 c.c. of rectified spirit, dried and weighed. The weight of the precipitate gives the total colloid content which is expressed as per cent on weight of juice.

Gums

Estimated by the method of Ruff and Withrow [1922] as follows : 50 c.c. of juice is concentrated to 50° Brix, 1 c.c. of concentrated HCl is added, followed by a slow addition of 100 c.c. rectified spirit, while the liquid is vigorously agitated. The precipitate is allowed to settle and filtered through asbestos and washed with rectified spirit. It is then dried and weighed. After this, it is ignited to complete combustion

and weighed. The loss in weight on ignition represents the gums which are expressed as per cent on juice weight.

Pectin

The method of Farmell [1924] is followed. 250 c.c. of juice are boiled for two minutes and filtered. The filtrate and washings are made up to 350 c.c. and then neutralised with N/10 NaOH. 15 c.c. of N/10 NaOH are added in excess and the solution left overnight. 12·5 c.c. of N acetic acid followed by 12·5 c.c. of M $CaCl_2$ solution are added and the juice boiled for two minutes. After leaving for 24 hours, the precipitate is washed sucrose free, boiled with 25 c.c. of hot water and filtered through a tarred filter paper. It is then dried and weighed and reported as calcium pectate per cent weight of juice.

Crude Protein

The percentage of total organic nitrogen (determined by Kjeldahl's method is multiplied by the factor 6·25, giving the percentage of crude protein on the weight of juice.

Ash

Determined as sulphated ash and reported as ash per cent juice weight, after deducting one-tenth from the weight of ash.

Phosphate

P_2O_5 is determined in the nitric acid extract of the ash by the ammonium molybdate precipitation method [Pemberton 1893 : 1894], the results being expressed as percents on weight of juice.

The results of analyses of the *gur* samples from different varieties pertaining to the first year are given in Table I and the analysis of the corresponding juices in Table IA. Tables II and IIA give the results for the second year, those of the third year having been omitted for brevity. Results of analyses of variance pertaining to the third year's data have, however, been depicted in Table III and the correlation coefficients between various characters of juice and *gur* (as obtained from the third year's data) shown in Tables IV to VI.

Discussion

In what follows, an attempt has been made to bring out any relationships that may appear as a result of these experiments, between the chemical criteria of juices and their claribility, as apparent from their *gur* qualities, the latter being judged from general features as well as the various quantitative physical and chemical criteria already enumerated. The results of the first season may be considered in detail. A perusal of the various columns in Table I leads to a classification of the *gur* from different varieties with respect to quality.

TABLE I

Showing different attributes of gur : *Season 1945-46*

Numbers	Variety	Sucrose per cent	Glucose per cent	Moisture per cent	Pore space in c.c./100g	Intensity of colour (N/4 solutions)	Turbidity (N/4 solutions)	Millieq. acid in 100 gm. *gur*	General observations
1	Co. 313	80·9	4·79	6·06	26·8	95	2·00	12·9	Hard, crystalline, taste good, colour golden yellow
2	Co. 383	80·4	6·42	5·10	20·2	150	2·04	14·2	Hard, crystalline, taste good, colour deep red
3	Co. 395	79·4	4·81	5·12	17·5	160	2·23	13·3	Hard, crystalline, taste good, colour deep red
4	Co.453	80·4	6·42	5·16	21·2	200	2·23	14·8	Hard not quite crystalline, taste good, colour dark chocolate
5	Co. 513	80·8	4·79	4·96	27·0	100	1·95	13·3	Hard, crystalline, taste good, colour golden yellow
6	B.O. 8	74·8	5·81	7·92	20·3	150	2·10	13·3	Hard, crystalline, taste good, colour deep red
7	B.O. 9	79·2	5·92	7·58	20·0	170	1·96	14·8	Hard, crystalline, taste good, colour deep red
8	B.O.10	73·4	5·31	6·72	17·6	170	2·15	14·2	Hard, crystalline, taste good, colour deep red
9	B.O.11	74·0	9·62	6·96	18·0	160	2·10	14·2	Hard, crystalline, taste good, colour, deep red
10	B.O.21	78·2	8·30	7·14	18·8	150	2·13	14·2	Hard, crystalline, taste good, colour deep red

Thus, the 'general observations' show that all the varieties give hard *gur* with good taste and with the exception of Co. 453, all are quite crystalline. There is, however, a large variation in colour ranging from golden yellow in the cases of Co. 313 and Co. 513 to dark chocolate for Co. 453, the rest being deep red. It may be concluded from the above that so far as the general features are concerned, Co. 313 and Co. 513 give the best *gur*, Co. 453 distinctly the worst, the rest being of average quality. The quantitative figures for colour intensity (photo-electric colorimeter readings) further confirm this classification, Co. 313 and Co. 513 showing considerably lower readings (95 and 100) as against 200 for Co. 453 and the other varieties showing intermediate values (150 to 170). As regards sucrose content, it will be seen that *gur* from Cos. 313, 383, 453 and 513 are the richest. While confirming the superiority of Cos. 313 and 513, this does not place Cos. 383 and 453 in inferior positions. The varieties associated with the least amounts of glucose are Cos. 313, 395 and 513, all the others being very much richer in this ingredient. The varieties Co. 313 and Co. 513 are, thus, seen to be associated with yet another characteristic of good quality. Moisture contents of the samples of *gur* from Cos. 313, 383, 395, 453 and 513 are the lowest and these are the most satisfactory ones with respect to this criterion. Acidity values are not conspicuously different for the different varieties. The values for 'turbidity of

standard solutions show that the least amounts of suspended impurities are present in Co. 313 and Co. 513 and B.O. 9 samples, while the reverse holds good for Co. 395 and Co. 453. Pore spaces are considerably higher for Co. 313 (26·8) and Co. 513 (27·0) which shows their greater openness in texture, denoting superior quality. Taking all these facts into consideration and bearing in mind that colour is a primary quality factor, it may be said that Cos. 313 and 513 are outstanding in respect of *gur* quality. Co. 453 is distinctly inferior while the rest are of average quality. In other words, the highest degree of claribility (as indicated by *gur* quality) is shown by the juices of Cos. 313 and 513, that of Co. 453 being particularly poor and the rest giving juices of fair claribility.

A reference to Table IA will show the chemical criteria of the juices of the different varieties.

TABLE IA

Showing different attributes of juices: Season 1945-46

Numbers	Variety	Sucrose per cent	Glucose per cent	Total colloids per cent	Gums per cent	Calcium pectate per cent	Crude protein per cent	Ash per cent	P_2O_5 per cent
1	Co. 313	17·28	0·44	0·415	0·089	0·015	0·335	0·48	0·018
2	Co. 383	17·64	0·46	0·592	0·104	0·021	0·364	0·54	0·013
3	Co. 395	18·21	0·48	0·640	0·104	0·021	0·364	0·54	0·013
4	Co. 453	19·48	0·48	0·798	0·122	0·023	0·434	0·58	0·014
5	Co. 513	18·21	0·44	0·396	0·082	0·014	0·300	0·46	0·016
6	B.O. 8	17·84	0·46	0·504	0·108	0·020	0·372	0·52	0·020
7	B.O. 9	17·64	0·48	0·510	0·104	0·021	0·364	0·56	0·018
8	B.O. 10	17·56	0·46	0·498	0·106	0·021	0·364	0·56	0·018
9	B.O. 11	18·90	0·48	0·516	0·104	0·019	0·380	0·54	0·020
10	B.O. 21	18·21	0·48	0·512	0·108	0·020	0·372	0·52	0·017

The highest sucrose is recorded by Co. 453 (19·48) as against 17·28 for Co. 313 and 18·21 for Co. 513. Glucose percentages are of the same order for all the varieties, showing that the differences in juice claribility must be attributed to factors other than sucrose and glucose.

The total colloid contents are least in Co. 313 (0·415) and Co. 513 (0·396) and the highest in Co. 453 (0·786), being almost double in magnitude. The other varieties show intermediate values ranging from 0·498 for B.O.10 to 0·640 in case of Co. 395. This clearly demonstrates that high total colloid contents induce poor claribility, and the same will be seen to hold good for the individual colloidal ingredients examined. Thus, the good claribility juices show the smallest gum contents—Co. 313 (0·089) and Co. 513 (0·082)—as opposed to the highest value for the juice of the poorest claribility—Co. 453 (0·122). The other varieties whose juices have been classed as of fair claribility show intermediate values, ranging from 0·104 to 0·108. In the

same way the pectin contents (calculated as calcium pectate) of Co. 313 (0·015) and Co. 513 (0·014) are the lowest, of Co. 453 (0·025) the highest, the rest lying between these extremes (0·019 to 0·021). Crude protein contents also show the same behaviour —Co. 313 (0·335) and Co. 513 (0·300) containing the smallest amounts, Co. 453 (0·434) the highest and the others varying between 0·364 and 0·380. It would, thus, be seen that good claribility is associated with low colloid, contents (total as well as individual colloids) and *vice versa.*

The amount of mineral matter affects the juice claribility as colloids do, as will be apparent from the fact that the ash contents of the high claribility juices are the lowest and *vice versa.* Co. 313 (0·48) Co. 513 (0·46); Co. 453 (0·59). The other varieties show values lying between these extremes. Phosphate contents do not show any such clear relationship but it may be said that Co. 453, which gives a juice of the worst claribility, is among the poorest in phosphate and the possibility of low phosphate characterising poor claribility is strongly indicated. The results of the second year given in Tables II and IIA lead to similar conclusions.

TABLE II

Showing different attributes of gur : *Season 1946-47*

Numbers	Variety	Sucrose per cent	Glucose per cent	Moisture per cent	Pore space in c.c. per 100 gm.	Colour reading (N/4 solution)	Turbidity (N/4 solution)	Millieq. acid in 100 gm.	General observations
1	Co. 313	79·8	5·13	4·70	23·4	97	2·04	13·3	Hard, crystalline, taste good, colour golden yellow
2	Co. 383	81·2	6·41	3·10	11·2	160	2·03	14·8	Hard, crystalline, taste good, colour deep red
3	Co. 395	82·0	6·70	3·74	8·0	165	2·04	15·2	Hard, crystalline, taste good, colour deep red
4	Co. 453	77·0	10·27	6·54	11·8	260	2·17	16·8	Hard, not quite crystalline, taste good, colour dark chocolate
5	Co. 508	78·0	5·50	5·60	18·1	100	2·00	13·8	Hard, crystalline, taste good, colour golden yellow
6	Co. 513	77·0	5·30	5·04	23·1	96	2·05	12·5	Hard, crystalline, taste good, colour golden yellow
7	B.O. 3	79·2	8·56	4·98	9·1	152	1·97	15·8	Hard, crystalline, taste good, colour deep red
8	B.O.10	79·4	7·33	2·86	7·1	180	2·00	16·4	Hard, crystalline, taste good colour deep red
9	B.O.11	82·8	6·70	4·22	15·9	175	2·00	14·8	Hard, crystalliue, taste good, colour deep red
10	B.O.15	78·0	7·00	4·54	16·9	185	2·05	15·3	Hard, crystalline, taste good, colour deep red
11	B.O.21	80·8	5·92	4·90	16·6	180	2·00	15·8	Hard, crystalline, taste good, colour deep red
12	B.O.24	81·2	6·16	4·50	9·6	178	2·03	15·8	Hard, crystalline, taste good, colour deep red

TABLE IIA

Showing different attributes of juices : Season 1946-47

Numbers	Variety	Sucrose per cent	Glucose per cent	Total colloids per cent	Gums per cent	Calcium pectate per cent	Crude protein per cent	Ash per cent	P_2O^5 per cent
1	Co. 313	18·06	0·46	0·368	0·077	0·014	0·322	0·45	0·026
2	Co. 383	17·68	0·48	0·536	0·098	0·020	0·379	0·54	0·018
3	Co. 395	18·07	0·48	0·553	0·101	0·021	0·387	0·53	0·024
4	Co. 453	18·22	0·45	0·792	0·123	0·027	0·459	0·62	0·021
5	Co. 508	18·15	0·43	0·405	0·081	0·017	0·363	0·43	0·029
6	Co. 513	18·07	0·45	0·350	0·081	0·013	0·338	0·44	0·026
7	B.O. 3	17·72	0·46	0·515	0·105	0·022	0·368	0·54	0·021
8	B. O. 10	18·20	0·47	0·569	0·104	0·020	0·396	0·51	0·023
9	B.O. 11	18·10	0·50	0·627	0·105	0·021	0·404	0·51	0·025
10	B.O. 15	18·03	0·44	0·608	0·106	0·018	0·387	0·53	0·023
11	B.O. 21	18·13	0·44	0·643	0·101	0·022	0·403	0·50	0·023
12	B.O. 24	17·61	0·47	0·500	0·101	0·020	0·347	0·52	0·020

Of the varieties examined for the first time, the *gur* quality and juice criteria of Co. 508 are on par with the best varieties Co. 313 and Co. 513. The others come under the category of average varieties.

The above preliminary observations throw sufficient light on the general trends of behaviour in respect of the bearing of chemical attributes of juices on *gur* quality. In order to eliminate the possibility of chance coincidences and to estimate the degree of association of juice characteristics with the different physical and chemical criteria of *gur*, statistically planned experiments were conducted in the third season with reference to four varieties (Cos. 313, 383, 453, 513) in four replications, using three treatments (*Uhindi* mucilage, castor seed and groundnut extracts) in each. The boiling conditions were carefully standardised, each pan being struck at the same temperature (118°C.), recorded with precision.

The detailed data obtained in the third year (omitted for brevity) show, in general, the same trend as in previous years. The analysis of variance (Table III) clearly indicates the following varietal characteristics in respect of different properties of the products.

TABLE III

Statistical comparison of the properties of gur from different varieties

Season 1947-48

Numbers	Varieties / Characters	Co. 313	Co. 513	Co. 453	Co. 383	Conclusions
1	Sucrose	80·2	80·9	79·2	76·1	CD at 5 per cent = 1·73 ; CD at 1 per cent = 2·33 At 5 per cent : Co. 513, Co. 313, Co. 453, Co. 383 At 1 per cent : Co. 513, Co. 313, Co. 453 Co. 383. Highly significant
2	Glucose	3·05	3·70	3·60	4·53	CD at 5 per cent = 0·62 ; CD at 1 per cent = 0·83 At 5 per cent : Co. 383, Co. 513, Co. 453 Co. 313 At 1 per cent : Co. 383, Co. 513, Co. 453, Co. 313. Highly significant
3	Moisture	4·50	4·61	4·80	4·48	CD at 5 per cent = 0·34 At 5 per cent : Co. 453, Co. 513, Co. 313, Co. 383. Not significant
4	Pore space	23·9	24·3	17·1	18·0	CD at 5 per cent = 2·161 ; CD at 1 per cent = 2·91 At 5 per cent : Co. 513, Co. 313, Co. 383, Co. 453 At 1 per cent : Co. 513, Co. 313, Co. 383 Co. 453. Highly significant
5	Colour (N/4 solution)	79	84	198	176	CD at 5 per cent = 10·8; CD at 1 per cent = 14·5 At 5 per cent : Co. 453 Co. 383 Co. 513 Co. 313 At 1 per cent : Co. 453 Co. 383 Co. 513 Co. 313. Highly significant
6	Turbidity (N/4 solution)	1·83	1·84	1·99	1·94	CD at 5 per cent = 0·05 ; CD at 1 per cent = 0·06 At 5 per cent : Co. 453, Co. 383, Co. 513, Co. 313 At 1 per cent : Co. 453, Co. 383, Co. 513 Co. 313. Highly significant
7	Acidity	14·6	13·9	15·0	15·1	CD at 5 per cent = 0·60 ; CD at 1 per cent = 0·80 At 5 per cent : Co. 383, Co. 453. Co. 313 Co. 513 At 1 per cent : Co. 383, Co. 453. Co. 313. Co.. 513. Highly significant
8	Ash	1·96	2·10	2·81	2·47	CD at 5 per cent = 0·13 ; CD at 1 per cent = 0·18 At 5 per cent : Co. 453, Co. 383, Co. 513, Co. 313 At 1 per cent : Co. 453, Co. 383, Co. 513, Co. 313. Highly significant
9	Nett rendement	70·3	69·9	65·7	63·1	CD at 5 per cent = 2·10 ; CD at 1 per cent = 2·82 At 5 per cent : Co. 313, Co. 513, Co. 453. Co. 383 At 1 per cent : Co. 313, Co. 513, Co. 453, Co. 383. Highly significant

In the analysis of variance referred to here the variation due to varieties was obtained after eliminating the variation due to treatments.

(1) Cos. 513, 313 and 453 are the richest in sucrose. Co. 383 being at a definitely lower level.

(2) Co. 383 shows the highest glucose and the rest are at a lower level.

(3) Moisture differences are not significant.

(4) Cos. 513 and 313 samples possess higher pore space values, the other two showing definitely low figures.

(5) Colour of Cos. 313 and 513 *gur* is low and that of Cos. 383 and 453 samples much higher (particularly the latter).

(6) Turbidity of solutions is low for Cos. 313 and 513 and high for the other two

(7) Acidity is lowest for Cos. 513 and 313.

(8) The above is true for ash contents as well.

(9) Nett rendements are highest for Cos. 313 and 513.

The above observations clearly demonstrate the superiority of Cos. 313 and 513 and the distinctly poorer quality of the other two. As between Cos. 313 and 513, the difference is not marked but among the other two inferiority of Co. 453 in respect of colour is distinctly seen, although sucrose and glucose figures speak against Co. 383.

Attempts have been made to correlate the different characters of *gur* with the various juice criteria. Correlation coefficients worked out *between* and *within* varieties (separately under each treatment) are incorporated in Tables IV, V, and VI which demonstrate the intimate relationships existing between the chemical criteria of juices and the characteristics of their end products. The harmful effect of high levels of colloidal matter (total colloids as also colloids of different categories, such as gums, pectin, crude proteins) and mineral substances (ash) on juice clarifiability and quality of product is very clearly seen, the beneficial influence of high phosphates being equally apparent in contrast. It will be noticed that these relationships are manifested in a relatively less ample measure in case of the castorseed and groundnut extract treatments (as compared to *bhindi* mucilage) and this is presumably due to the enhanced degree of juice purification resulting from these treatments on account of which the deleterious ingredients are removed to a larger extent, thus reducing varietal differences in the clarified juices, and rendering their effects on the end product less pronounced as a consequence. The fact that phosphates (a beneficial ingredient) influence the characters of the product in practically the same manner under all three treatments is noteworthy in this connection.

Considering the above, it may be concluded that varietal juice characteristics associated with high clarifiability and quality of product are :

1. A low level of colloidal matter (total as well as individual colloids) and ash content.

2. A high level of phosphates.

Table IV

Showing correlation coefficients between different characters of gur *and those of juice*

Varieties ; Co. 313, 383, 453 and 513

Treatment : Bhindi mucilage

Numbers	Character of *gur* / Character of juice	Sucrose	Glucose	Moisture	Ash	Colour N/4 solution	Turbidity N/4 solution	Acidity	Pore space	Nett rendement
1	Sucrose	+0·9686*	—0·9603*	—0·1812	—0·5273	—0·5802	—0·5252	—0·4504	+0·6370	+0·9169
		+0·6832*	—0·5538*	—0·3937	+0·1282	—0·3217	+0·0234	—0·1984	—0·2273	+0·7213**
2	Glucose	—0·7808	+0·9560*	+0·2174	+0·1801	+0·2179	+0·1840	+0·1077	—0·2735	—0·6859
		—0·3712	—0·0475	+0·0740	—0·1243	—0·1958	+0·0779	+0·2057	+0·0518	—0·4229
3	Total colloids	—0·6004	+0·3071	+0·3165	+0·9863*	+0·9833*	+0·9703*	+0·9461	—0·9591*	—0·7497
		—0·1266	—0·2093	+0·1136	+0·1604	—0·3309	—0·4012	+0·0220	+0·1501	—0·0993
4	Gums	—0·5946	+0·3198	+0·3599	+0·9908**	+0·6663	+0·9868*	+0·9908**	—0·9527*	—0·7504
		+0·1384	+0·4413	—0·0501	+0·1455	+0·5016	+0·3914	—0·3497	—0·0568	—0·1638
5	Pectin (Calcium pectate)	—0·6009	+0·3383	+0·2309	+0·9825*	+0·9912**	+0·9882*	+0·9871*	—0·9780*	—0·7819
		—0·9484**	+0·2590	—0·7754**	+0·6059*	—0·2513	+0·7055**	—0·4365	—0·1357	+0·5121
6	Crude protein	—0·5967	+0·2089	+0·0550	+0·9202	+0·9501*	+0·9871*	+0·8999	—0·9520*	—0·7051
		+0·5224	+0·5540*	—0·3416	+0·1784	—0·0759	+0·2138	—0·8415**	—0·3553	+0·1776
7	Ash	—0·0766	+0·4879	+0·2682	+0·9818*	+0·9988**	+0·9842*	+0·9548*	—0·9974**	—0·8756
		—0·0322	—0·3128	+0·1203	—0·2861	—0·0459	—0·2739	—0·1360	—0·5344	—0·2113
8	P_2O_5	+0·7584	—0·4831	—0·2822	—0·9852*	—0·9987**	—0·9842*	—0·9623*	+0·997**	+0·8712
		+0·3486	+0·1477	—0·5139	+0·4326	—0·4359	—0·0180	—0·5850*	+0·1487	+0·2971

The upper figures indicate correlation coefficients ' between varieties '
The lower figures indicate correlation coefficients ' within varieties '
*Shows significance at 5 per cent level
**Shows significance at 1 per cent level

TABLE V

Showing correlation coefficients between different characters of gur *and those of juice*

Varieties : Cos. 313, 383, 453, 513

Treatment : Castor seed extract

Numbers	Character of *gur* / Character of juice	Sucrose	Glucose	Moisture	Ash	Colour N/4 solution	Turbidity N/4 solution	Acidity	Pore space	Nett rendement
1	Sucrose	+0·9305	—0·9709*	+0·3665	—0·5083	—0·7296	—0·6220	—0·6862	+0·7038	+0·9469
		+0·4798	—0·2071	—0·5105	+0·0254	+0·5135	—0·5289	+0·3463	—0·1386	+0·5735*
2	Glucose	—0·8197	+0·9802*	—0·6399	+0·1648	+0·3965	+0·3028	+0·4888	—0·3567	—0·1370
		—0·1674	+0·0437	—0·3711	—0·2372	+0·3173	—0·4480	—0·5553*	+0·1435	—0·7146**
3	Total colloid	—0·3195	+0·2229	+0·6651	+0·9849*	+0·9253	+0·9581*	+0·3435	—0·8756	—0·4916
		—0·1927	—0·2239	+0·2566	—0·2551	—0·2013	+0·2065	+0·2447	+0·2494	—0·1760
4	Gums	—0·3038	+0·2293	+0·6733	+0·9905**	+0·2015	+0·9647*	+0·3103	—0·0250	—0·6586
		+0·0838	+0·3813	—0·1866	+0·0894	—0·1257	+0·1304	—0·3875	—0·2715	+0·2000
5	Pectin (Calcium pectate)	—0·3899	+0·2665	+0·6097	+0·9776*	+0·9471	+0·9569*	+0·4227	—0·9548*	—0·7113
		+0·2103	+0·1866	—0·4273	+0·5906*	—0·3750	+0·0286	—0·3891	+0·0825	+0·2054
6	Crude protein	—0·3828	+0·1627	+0·6346	+0·9107	+0·9026	+0·8765	+0·2883	—0·9242	—0·6613
		+0·3919	+0·4732	—0·2544	+0·1027	—0·3989	+0·0423	—0·6669*	—0·3577	—0·1882
7	Ash	—0·5250	+0·4247	+0·4779	+0·9737*	+0·9775*	+0·9769*	+0·5069	—0·9880*	—0·8174
		—0·4555	—0·2975	—0·3224	—0·2468	+2712	—0·0931	+0·1160	+0·3606	—0·3677
8	P_2O_5	+0·5108	—0·4170	—0·4907	—0·9781*	—0·9858*	—0·9820*	—0·4875	+0·9874*	+0·8098
		+0·0960	+0·1066	—0·1218	+0·4444	—0·2200	—0·5861	—0·2593	+0·4454	+0·0942

The upper figures indicate correlation coefficients ' between varieties '
The lower figures indicate correlation coefficients ' within varieties '
*Shows significance at 5 per cent level
**Shows significance at 1 per cent level

TABLE VI

Showing correlation coefficients between different characters of gur *and those of juice*

Varieties : Cos. 313, 383, 453, 513

Treatment : Groundnut extract

Numbers	Character of *gur* / Character of juice	Sucrose	Glucose	Moisture	Ash	Colour N/4 solution	Turbidity N/4 solution	Acidity	Pore space	Nett rendement
1	Sucrose	+0·9013	—0·8971	+0·4206	—0·0075	—0·7914	—0·6027	—0·5155	+0·7489	+0·8926
		+0·4112	+0·0415	—0·4750	—0·9930**	—0·1512	—0·1998	+0·1235	—0·1685	+0·4761
2	Glucose	—0·7420	+0·8470	—0·7526	+0·1083	+0·4804	+0·2944	+0·1952	+0·3491	+0·6274
		—0·5794	—0·0801	+0·2522	—0·1427	—0·0327	—0·0729	+0·3379	—0·4139	—0·7017**
3	Total Colloids	—0·4027	+0·4703	+0·5705	+0·9937**	+0·8856	+0·9542*	+0·4876	—0·8997	—0·7513
		—0·2329	—0·1105	—0·0057	—0·2242	—0·1228	—0·5436	+0·3019	+0·3621	—0·2947
4	Gums	—0·3834	+0·4907	—0·6518	+0·9973**	+0·8822	+0·7639	+0·5584	—0·8918	—0·7430
		+0·3117	+0·5178	—0·2364	+0·1424	+0·4169	+0·2672	—0·1605	—0·1641	+0·1789
5	Pectin (Calcium pectate)	—0·4740	+0·4815	+0·5539	+0·9865*	+0·9121	+0·9480	+0·6571	—0·9293	—0·8059
		+0·2567	+0·4490	—0·0637	+0·6390*	—0·3679	+0·5163	—0·2326	+0·0798	+0·2252
6	Crude protein	—0·4847	+0·3236	+0·6647	+0·9310	+0·8618	+0·8613	+0·7631	—0·9011	—0·7590
		+0·4582	+0·7189**	—0·0888	+0·1902	+0·0407	+0·1088	—0·5108	—0·1933	+0·2961
7	Ash	—0·5943	+0·6050	+0·4148	+0·9731*	+0·9679*	+0·9673*	+0·6840	—0·9749*	—0·9819
		—0·4545	—0·2411	—0·3836	—0·2485	—0·0733	—0·1620	—0·1621	—0·2658	—0·4608
8	P_2O_5	+0·5808	—0·5986	—0·4187	—0·9773*	—0·9648*	—0·9839*	—0·6696	+0·9709*	+0·8751
		+0·1503	+0·4172	+0·0988	+0·4354	—0·2930	+0·3586	—0·7073**	+0·5682*	+0·1034

The upper figures indicate correlation coefficients ' between varieties '
The lower figures indicate correlation coefficients ' within varieties '
*Shows significance at 5 per cent level
**Shows significance at 1 per cent level

Summary

It is common experience in *gur* manufcture to find large variations in the quality of *gur* resulting from different varieties of cane and these differences in juice claribility are not usually traceable to sucrose differences, being attributed to colloidal non-sugar juice constituents which are known to play an important role in the vacuum pan process. As the effective methods for their elimination inherent in this process are not available in the open pan system of manufacture, the importance of these constituents is far greater in the open pan industry which may crush only such varieties as would provide juices of the highest degree of claribility. These investigations were, therefore, undertaken over three successive crushing seasons with the object of ascertaining the chemical criteria associated with juices of different degrees of claribility (with respect to a number of important varieties of cane)—so as to ultimately arrive at the optimum characteristics required of juices to be crushed for open pan boiling.

As a result of these experiments, the following important relationships are observed :

Juices of good claribility contain colloidal matter (*total*) in small amounts and the same holds good for individual colloidal ingredients such as gums and pectin. They are also characterized by low ash and high P_2O_5 contents. The reverse characteristics are associated with juices of poor claribility while those possessing a fair degree of claribility show an intermediate behaviour in all respects.

These experiments also point to the varieties Co. 313, Co. 508 and Co. 513 as giving juices of the highest degree of claribility and they must be considered to be pre-eminently suited for the open pan process of manufacture.

Acknowledgments

This work was carried out as part of the Sugarcane Research Scheme in Bihar being financed jointly by the Bihar Government and the Indian Central Sugarcane Committee, to whom grateful thanks are due. The assistance rendered by Mr. K. S. Bandyopadhyay, Statistician, in statistically analysing the data presented in this paper is also acknowledged.

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STUDIES ON THE SUGARCANE DISEASES IN INDIA

I. SUGARCANE MOSAIC VIRUS

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(Received for publication on 7 January 1942)

(With Plate I)

THERE is much information available in literature on various aspects of sugarcane mosaic disease but the information regarding the sugarcane mosaic virus itself is meagre. It is probably owing to the fact that the reproduction of the disease through artificial transmission, which is essential for the study of the properties of any virus, is attended, in the case of sugarcane mosaic virus, with great difficulty [Matz, 1919 ; Smyth, 1920 ; Lyon, 1921 ; Bruner, 1922 and Sein, 1930].

In the following pages are presented the results of experiments, extending over five years, with sugarcane mosaic virus, which, it is hoped, will throw light on the factors influencing the virulence of the mosaic virus in the juice extracted from mosaic affected cane plants and may explain to some extent the great variations in the results obtained by various authors working on this disease of cane. In an earlier communication from these laboratories by one of the authors [Rafay, 1935], preliminary information regarding some physical properties of this mosaic virus was presented.

Materials and methods

The inoculum was prepared from the uppermost three or four fully unfolded leaves, showing clear mottling, of young cane plants or from tillers of the old infected plants. These leaves were trimmed at either end, cut into small pieces and crushed in pestle and mortar adding ice-cold distilled water gradually at the rate of 1·c. c. per gram of leaf tissue, till reduced to a fine pulp. The juice was extracted from the pulp by pressing it with hand through cheese cloth. The beaker in which the juice was collected was kept jacketed with ice. All the apparatus used in these operations was suitably sterilized.

As any attempt at purification or clarification of the juice would have meant some lapse of time, which would have greatly decreased the virulence of the virus

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principle, the juice was used as extracted, in the crude form. As a rule inoculations were made as soon as the juice was ready but in cases of any unvoidable delay the expressed juice was stored at about 6°C. in the frigidaire.

Inoculations were made by the method described by Matz [1933] but with a slight modification. In this method the juice is dropped in the 'cup' formed by the first unfolded leaf round the spindle and pricked through with a fine entomological pin. The modification consists in having about 20 pins mounted on a small velvet cork, instead of using the pin or needle singly for pricking, with the result that 20 prick-punctures are obtained with a single stroke. The spindle is pricked ten or twelve times, i.e., in all about 200 punctures are made in the tissue in each inoculation.

Young cane plants, about two to three weeks old, in the fourth or fifth leaf-stage, were, as a rule, used for inoculation purposes. Sometimes young plants of *jowar* (*Sorghum vulgare*) or maize (*Zea mays*) were substituted for cane plants, as these were easier to raise and moreover afforded a longer working period, for preliminary tests; but all such results were eventually confirmed on cane plants.

Almost entire absence of natural transmission both at Pusa and Delhi, where these experiments were conducted, made it possible to do the work out of doors.

Experimental

Properties of the sugarcane mosaic virus filterability

Filtration through L_3 Pasteur Chamberland candles. In order to test the filtrability of sugarcane mosaic virus through L_3 filter candles, sugarcane mosaic leaf juice was filtered first through filter paper (Whatman's No. 42) impregnated with Kieselguhr when a clear brown amber-coloured filtrate was obtained, then through an L_3 Pasteur Chamberland candle under reduced pressure of five inches of mercury.

The filtrate thus obtained was tested on young cane, maize and *jowar* plants several times every year, during the most favourable periods of artificial transmission but no successful infection was ever obtained while the corresponding untreated mosaic juice always showed over 50 per cent infectivity.

The non-infectivity of L_3 filtrate suggests two possibilities:

(1) That the infective principle is held back in the Chamberland filter candle owing to adsorption due to negative electrical charge of the virus particles.

(2) That the virus particles are too large to pass through the pores of an L_3 candle.

Filtration through Berkfeld filter. If the infiltrability of the sugarcane mosaic virus through Chamberland filter (L_3) is ascribed to adsorption of the virus on the filter walls owing to a negative electrical charge of the virus particles, the virus should be able to pass through Berkfeld filters which are known to hold back particles carrying positive electrical charges only and allow passage of negatively charged

particles. Attempts were, therefore, made to filter sugarcane mosaic virus through Berkfeld filters (V grade, the coarsest of the series).

In one of the experiments, mosaic leaf juice (Co. 213) was centrifuged for half an hour at 3,000 revolutions per minute, to clear it of the suspended cell debris, and the supernatant liquid was filtered through a Berkfeld V candle. The filtrate when inoculated into young maize plants, proved to be non-inefective while the mosaic juice and its supernatant liquid produced eighty per cent successful infection.

Similar results were obtained when young cane plants were used instead of maize plants for testing the infectivity of the filtrate. Inability of the virus to pass through, even Berkfeld filter rules out the possibility No. 1., i.e., the virus is held back in the L_3 Candle filter owing to adsorption.

Filtration through coarser filters, Seitz filter. Mosaic leaf juice (Co. 213) was filtered through a Seitz filter (No. 6). The residue held back was suspended in water. The filtrate, the residue suspension and mosaic juice were separately inoculated into maize plants to test their infectivity. The mosaic juice and the residue produced typical mosaic mottling on inoculated plants but the filtrate proved non-infectious.

Filtration through filter paper. Filtration tests with sugarcane mosaic juice through ordinary filter paper (Whatman's filter paper No. 42) showed that the mosaic juice after one filtration retained a slight greenish tinge in the filtrate which was found fairly infectious. But if the filtrate was poured over the same filter funnel again, the ultimate filtrate was a clear amber-coloured liquid. This clear filtrate always proved to be non-infectious. The juice when filtered twice resulted in the clear amber-coloured filtrate and very rarely it was found necessary to filter it a third time. Whenever any greenish tinge was present in the filtrate, it was found to be infectious.

The residue on the filter paper was thoroughly washed with distilled water and then tested for infectivity. It proved on inoculation, almost as infectious as the mosaic juice and produced typical mosaic mottling on the test plants. Data of these experiments are given in Table I.

In the experiments described above, repeated failure of infection with various filtrates obtained by passage of the virus-containing fluid through L_3 Chamberland Berkfeld (V), Seitz candles and even through ordinary filter paper, clearly indicated that sugarcane mosaic virus was not a filterable one. Chester [1937] also reports sugarcane mosaic virus as serologically inactive, which is ascribed to lack of virus antigen in the juice or antigenic inactivity of the virus juice.

Positive infection with residue held back by the filters and with filter paper filtrate, whenever it possessed even the slightest green tinge, showed that the infective principle of sugarcane mosaic virus was absorbed on the chlorophyll bearing tissue and was firmly held there.

Dilution

Effect of dilution. To determine the dilution-end-point of sugarcane mosaic virus various dilutions of the mosaic leaf juice were made with sterile distilled water

and tested for their infectivity on young cane or maize plants. The results of a few typical experiments, carried out from time to time, are presented in Table II.

TABLE I

Filtration tests of sugarcane mosaic virus with filter paper

Date of Inoculation	Inoculum	Test plants	Number of plants inoculated	Number infected
24-5-34	Co. 213 mosaic juice	Cane Co. (213)	10	5
	Co. 213 mosaic juice filter paper filtrate (clear amber)	do.	10	0
	Co. 213 mosaic juice filter paper residue suspended in water	do.	10	5
6-4-36	Co. 213 mosaic juice	do.	20	18
	Co. 213 mosaic juice filter paper filtrate (greenish)	do.	20	14
	Co. 213 mosaic juice filter paper filtrate (clear amber)	do.	20	0
6-5-36	Co. 213 mosaic juice	Maize	25	23
	Co. 213 mosaic juice filter paper filtrate (clear amber)	do.	25	0

TABLE II

Effect of dilution on infectivity of sugarcane mosaic virus

Date of inoculation	Inoculum	Dilution	Test plants	Number of plants inoculated	Number infected
May, 1934	Co. 213 mosaic juice	Undiluted	Cane (Co. 213)	10	8
	do.	1 : 10	do.	10	4
	do.	1 : 100	do.	10	0
	do.	1 : 1000	do.	10	0
	do.	1 : 10,000	do.	10	
	do.	1 : 100,000	do.	10	0
	do.	1 : 1,000,000	do.	10	0
May, 1936	do.	Undiluted	Maize	30	27
	do.	1 : 10	do.	30	22
	do.	1 : 50	do.	30	10
	do.	1 : 1,00	do.	30	8
	do.	1 : 1,000	do.	30	0
August, 1937	do.	Undiluted	Cane (Co. 213)	16	6
	do.	1 : 10	do.	16	5
	do.	1 : 50	do.	16	1
	do.	1 : 100	do.	16	0
	do.	1 : 500	do.	16	0

From the above table it is clear that the power of infection of sugarcane mosaic virus rapidly falls off with dilution. Even a dilution as low as 1 : 10 greatly reduces its infectivity and at 1 : 100 the virus principle in the juice becomes non-infectious on young cane plants. However, when maize plants instead of cane plants were used, slight amount of infection was produced by the juice even at 1 : 100 dilution. Presumably maize is more susceptible than cane.

Similar results were obtained with *Saretha* (an indigenous thin reed cane) mosaic juice. Infectivity of the juice fell from 100 per cent (undiluted mosaic juice) to 36 per cent at 1 : 10 dilution and to 18 per cent at 1 : 100 when tested on young maize plants. Dilutions greater than 1 : 100 failed to produce any infection.

Dilution tests with Co. 313 and M. 16 mosaic juices revealed that their dilution-end-points are higher than that of Co. 213 as is clear from Table III. In this experiment the mosaic juice of Co. 213, Co. 313 and M. 16 were inoculated into young maize plants in various dilutions in August, 1937. Sixteen maize plants were ino- culated with each dilution of the three mosaic juices.

TABLE III

Dilution-end-point of Co. 213, Co. 313 and M. 16 mosaic juice

Date of Inoculation	Dilution	Test plants	Co. 213 mosaic juice		Co. 313 mosaic juice		M. 16 mosaic juice	
			Number of plants inoculated	Number infected	Number of plants inoculated	Number infected	Number of plants inoculated	Number infected
August, 1937	Undiluted	Maize	16	6	16	10	16	14
	1 : 10	,,	16	5	16	7	16	8
	1 : 50	,,	16	0	16	2	16	4
	1 : 100	,,	16	0	16	1	16	3
	1 : 500	,,	16	0	16	0	16	0

It is evident that Co. 313 and M. 16 mosaic juices can stand dilution better than Co. 213 ; also that they are more virulent than Co. 213 as they cause more infection even in undiluted form than Co. 213. It will be seen later that the three mosaic juices represent different strains of sugarcane mosaic virus.

Centrifuging

During 1935-36 season two experiments were carried out to study the effect of centrifuging on Co. 213 mosaic juice ; one at 2,500 r.p.m. and the second at 1,500 r.p.m. ; the duration of centrifuging being five minutes in each case. The supernatant liquid and the sediment, after being thoroughly washed with distilled water, were tested for infectivity by inoculating Co. 213 and maize plants in the first and second experiments respectively.

No infection was obtained with the sediment in either of the two experiments while the supernatant liquid and the untreated mosaic juice produced 20 per cent infection on cane and 67 per cent infection on maize test plants.

In order to test the effect of centrifuging for a longer period Co. 313 mosaic juice was centrifuged at 3,000 r.p.m. for 30 minutes and 60 minutes, and the supernatant liquid and the residue tested for their infectivity on young Co. 313 cane plants. Supernatant liquid in both the cases gave 60 per cent infection. A similar degree of infection was obtained with the untreated mosaic juice. The sediment in these experiments when washed and mixed with distilled water and tested for infectivity gave successful mosaic infection, clearly indicating precipitation, to some extent, of the virus through prolonged centrifuging.

In further experiments it was observed that the sediment from Co. 313 mosaic juice during the first five minutes of centrifuging at 3,000 r.p.m. was not infectious, while that settled in ten minutes time gave successful mosaic infection. It would therefore be expected that centrifuging the mosaic juice for longer periods should bring down a considerable amount of infectious material, depleting the supernatant liquid of its mosaic virus concentration.

The absence of any such depletion in the superntant liquid even after 60 minutes of centrifuging in the above experiment points to the possibility of the infectivity test being not sensitive enough. In these experiments infectivity has been measured, in the absence of the production of any necrotic spots by this virus on the inoculated leaves, by inoculating a number of host plants at a suitable stage of growth for susceptibility, during the period most favourable to artificial transmission of the disease, and then judging from the number of resulting infections as to which of the two inocula tested contained the larger proportion of virus in a given volume. While the accuracy of this procedure is sufficient to differentiate between strong and weak samples of virus it may fail to give decisive results with samples differing but very slightly in their virus concentrations above the critical dilution. With this end in view an experiment was conducted in February, 1938, when centrifuging for various periods was effected and the supernatant liquids were used as such as well as in different dilutions.

Co. 313 mosaic juice was centrifuged at 3,000 r.p.m. for 30, 45 and 60 minutes. The supernatant liquids were inoculated as such (undiluted) as well as at dilutions of 1 : 20 and 1 : 100, into young Co. 313 cane plants to test their infectivity. Ten cane plants were inoculated in each case and these were placed in a glazed chamber registering a temperature of 25°C.-40°C. during the most part of the day. The results obtained are given in Table IV.

It is evident from the table that sugarcane mosaic juice can be centrifuged only for half-an-hour at 3,000 r. p. m. without demonstrable loss of virulence.

Longevity

It was found early in the course of our investigations on sugarcane mosaic virus that the mosaic juice became non-infectious in a very short time after its extraction

TABLE IV

Effect of centrifuging on infectivity of sugarcane mosaic virus

Inoculum	Supernatant liquid					
	Undiluted		Diluted (1 : 20)		Diluted 1 : 100	
	Number of plants inoculated	Number infected	Number of plants inoculated	Number infected	Number of plants inoculated	Number infected
Co. 313 mosaic juice (untreated control)	10	10	10	4	10	2
Co. 313 mosaic juice centrifuged 30 minutes	10	5	10	2	10	2
Co. 313 mosaic juice centrifuged 45 minutes	10	6	10	0	10	0
Co. 313 mosaic juice centrifuged 60 minutes	10	6	10	0	10	0

from the leaf tissue. To determine the longevity *in vitro* of sugarcane mosaic virus, extracted juice (Co. 213) was stored at 20° C. and was tested for infectivity on young cane plants after various lengths of time. Ten cane plants were inoculated with each lot in May, 1934. The results obtained are given in Table V.

TABLE V

Effect of storrage on the infectivity of sugarcane mosaic virus (Co. 213)

Storage period	Test plants	Number of plants inoculated	Number of plants infected
Ten minutes	Cane (Co. 213)	10	5
Thirty minutes	do.	10	4
One hour	do.	10	4
Two hours	do.	10	0
Three hours	do.	10	0
Six hours	do.	10	0
Twelve hours	do.	10	0
Twenty-four hours	do.	10	0

It is evident from the above data that sugarcane mosaic virus *in vitro* is relatively unstable, its storage life is very limited and that Co. 213 mosaic juice loses its virulence within two hours of its extraction. It means that inoculations in any experiments on the study of the properties of this virus must be completed within one hour.

Similar experiments during June, 1938 with Co. 313 mosaic juice stored at room temperature (30-32°C.) and using cane and maize as test plants, revealed that undiluted juice remains infectious for five hours at 32°C. and even at the end of six-hours storage, it is virulent enough to infect maize plants. This is an additional evidence in support of the view that there exist in India several strains of sugarcane mosaic virus and that Co. 213 and Co. 313 mosaic viruses are quite distinct from one another. The results of the tests with Co. 313 mosaic juice are set out in Table VI.

TABLE VI

Effect of storage on the virulence of sugarcane mosaic virus (Co. 313)

Storage period	Number of maize plants inoculated	Number infected	Number of cane plants inoculated	Number infected
Fifteen minutes	20	20	10	9
Two hours	20	19	Not tested	—
Three hours	20	16	10	4
Four hours	20	16	Not tested	—
Five hours	20	12	10	2
Six hours	20	2	10	0

In order to determine the cause of such rapid inactivation of sugar mosaic virus, the effect of oxidation on the virus was studied as inactivation of even a resistant virus like that of tobacco mosaic is known to be caused by oxidative changes [Johnson, 1926]. The effect of hydrogen peroxide (12 vol.) on the sugarcane mosaic juice was tested during May 1934. In all these experiments 20 minutes' interaction of the mosaic juice and hydrogen peroxide was allowed. The results obtained are given in Table VII.

TABLE VII

Effect of hydrogen peroxide on sugarcane mosaic virus

Inoculum	Test plants	Number of plants inoculated	Number infected
Co. 213 undiluted mosaic juice (control)	Co. 213	10	5
Co. 213 mosaic juice treated with hydrogen peroxide (1 part hydrogen peroxide and 49 parts juice)	,,	10	4
Co. 213 mosaic juice treated with hydrogen peroxide (1 part hydrogen peroxide and 24 parts juice)	,,	10	0

It is interesting to note that a strong oxidising agent such as hydrogen peroxide had practically no effect on sugarcane mosaic virus in 1 : 50 concentration. Evidently this virus which is readily inactiviated by dilution and ageing, is markedly resistant to the inactivating influence of oxygen.

As inactivation of the virus does not appear to be an oxidative process, the effect of temperature on the storage life of sugarcane mosaic virus was studied and it was found that storage temperature is the most important factor determining the longevity of the virus *in vitro* : the lower the storage temperature the longer is the period for which the mosaic virus will retain its infectivity.

In a preliminary experiment during May, 1936, when mosaic juice (Co. 213) was stored in ice and then inoculated into cane plants at different intervals, it was found that even after 48 hours' storage at 0°C. (the longest under test that season) the mosaic juice proved to be infectious. When the storage temperature was about 10°C. the juice was found to have lost its infectivity completely after 48 hours. However, mosaic affected leaves (Co. 213) severed from the plant and stored under similar conditions were found to contain active mosaic virus even after a lapse of 144 hours.

In similar experiments carried out with Co. 313 mosaic juice, during 1936-37 it was found that Co. 313 mosaic juice stored at 5-6°C. remained infective even after 96 hours' storage.

During 1937-38 season, mosaic juice of Co. 213 and Co. 313 were stored at low temperature (5-6°C) for various lengths of time and then inoculated into young cane and maize plants to test for their infectivity. The results obtained are given in Table VIII.

TABLE VIII

Effect of low temperature on storage life of sugarcane mosaic virus

Inoculum	Test plants	Number of plants inoculated	Number infected
Co. 213 mosaic juice (fresh)	Maize	10	3
Co. 213 mosaic juice after 48 hours' storage (5-6°C)	,,	10	9
Co. 313 mosaic juice (fresh)	,,	10	5
Co. 313 mosaic juice after 48 hours' storage (5-6°C)	,,	10	9
Co. 313 mosaic juice (fresh)	Cane (Co. 313)	10	1
Co. 313 mosaic juice after 48 hours' storage (5-6°C)	do.	10	3

During 1938-39 season, Co. 313 mosaic juice was stored at low temperature (5-6°C.) to study the effect of storage over longer periods. After six, eight, and eleven days' storage the mosaic juice, undiluted and at a dilution of 1 : 20, was tested for infectivity on young cane plants (Co. 313). It was found that after six days' storage both the juices were still infectious, but by the eighth day the diluted juice was rendered indactive while the undiluted sap did not lose its infectivity until the eleventh day. Data are given in Table IX.

TABLE IX

Effect of storage at 5-6°C. on the infectivity of sugarcane mosaic virus

Inoculum	Test plants	Undiluted		Diluted (1 : 20)	
		Number of plants inoculated	Number infected	Number of plants inoculated	Number infected
Co. 313 mosaic juice (fresh)	Cane (Co. 313)	20	14	20	10
Co. 313 mosaic juice after six days' storage	do.	20	13	20	10
Co. 313 mosaic juice after eight days' storage	do.	20	6	20	0
Co. 313 mosaic juice after eleven days' storage	do.	20	0	20	0

It will be seen from the above data that Co. 213 and Co. 313 mosaic juices which lose their infectivity after two hours' and six hours' storage at room temperature (30-32°C.), respectively, retain infectivity for several days when stored at a low temperature. .

Mosaic leaves stored at low temperature

Experiments were also carried out with mosaic affected leaves severed from the plant and stored at low temperature (5-6°C.) for various lengths of time and then tested for infectivity of the mosaic virus by inoculating the sap extracted from these leaves into young cane plants. It was found that the leaves thus stored retained the virus in an active form even after a storage of two weeks.

Results of a typical experiment conducted during 1936-37 with Co. 213 mosaic leaves stored at 5-6°C. are given in Table X.

TABLE X

Longevity of sugarcane mosaic virus (Co. 213) in leaves stored at 5-6°C.

Inoculum	Test plants	Number of plants inoculated	Number infected
Co. 213 mosaic juice (fresh leaves)	Cane (Co. 213)	10	5
Co. 213 mosaic juice (leaves stored for 48 hours)	do.	10	9
Co. 213 mosaic juice (leaves stored for 96 hours)	do.	10	7
Co. 213 mosaic juice (leaves stored for 312 hours)	do.	10	5

In similar experiments with Co. 313 during 1938-39 season the mosaic leaves were stored at low temperature (5-6°C.) and after six, eight and eleven days of storage juice from the stored leaves was extracted and tested for infectivity. It was observed that the mosaic juice from leaves after six and eight days' storage was found to be infectious when undiluted and at a dilution of 1 : 20. The undiluted juice from stored leaves was found to be virulent even after a storage of eleven days but the dilution of 1 : 20 rendered it non-infectious. The results are given in Table XI.

It will be evident from the above experiments that extracted mosaic juice as well as the mosaic leaves when stored at low temperatures retain the virus in a viable form for a considerably long time ; also that the virus in the extracted juice stored at low temperature loses virulence earlier than the stored leaves. With higher storage temperature (30-32°C.) the mosaic juice loses its infectivity in a much shorter time. It may be safely concluded that the temperature is the most important factor in the longevity *in vitro* of sugarcane mosaic virus ; the lower the temperature the longer is the period the mosaic virus can remain viable.

TABLE XI

Longevity of sugarcane mosaic virus (Co. 313) in leaves stored at 5-6°C.

Inoculum	Test plants	Undiluted		Diluted (1 : 20)	
		Number of plants inoculated	Number infected	Number of plants inoculated	Number infected
Co. 313 mosaic juice (fresh leaves)	Cane (Co. 313)	20	14	20	10
Co. 313 mosaic juice (leaves stored for six days)	do.	20	16	20	12
Co. 313 mosaic juice (leaves stored for eight days)	do.	20	12	20	3
Co. 313 mosaic juice (leaves stored for eleven days)	do.	20	6	20	0

RESISTANCE TO HEAT

To determine the thermal-death-point of sugarcane mosaic virus, 5 c. c. of the mosaic juice was heated in thin-walled test tubes in a water bath for ten minutes at the desired temperature after which the tubes were plunged in cold water and then inoculated into young cane or maize plants to test its infectivity.

Results of the experiments conducted with Co. 213 mosaic juice from time to time are set out in Table XII.

TABLE XII

Effect of temperature on the infectivity of sugarcane mosaic virus (Co. 213)

Date of inoculation	Inoculum	Test plants	Number of plants inoculated	Number infected
9 May, 1935	Co. 213 mosaic juice (untreated control)	Cane (Co. 213)	10	2
	Co. 213 mosaic juice heated at 50°C.	do.	10	0
	Co. 213 mosaic juice heated at 60°C.	do.	10	0
	Co. 213 mosaic juice heated at 70°C.	do.	10	0
24 June, 1935	Co. 213 mosaic juice (untreated control)	Maize	10	9
	Co. 213 mosaic juice heated at 40°C.	do.	10	6
	Co. 213 mosaic juice heated at 45°C.	do.	10	0
June, 1938	Co. 213 mosaic juice (untreated control)	Cane (Co. 313)	10	8
	Co. 213 mosaic juice heated at 40°C.	do.	10	6
	Co. 213 mosaic juice heated at 45°C.	do.	10	0
	Co. 213 mosaic juice heated at 50°C.	do.	10	0

It would be clear that the thermal-death-point of Co. 213 mosaic virus lies between 40°C. and 45°C. which shows that this virus behaves in its resistance to heat like the tomato spotted wilt virus and the crinkle and mild mosaic viruses of potato and thus ranks amongst one of the most sensitive plant viruses.

Similar experiments with mosaic juices of various cane varieties namely Co. 213, 313, M. 16, Red Mauritius and *Saretha*, a thin indigenous reed cane, were conducted during 1935-37. The mosaic juices were exposed for ten minutes at 40°, 45°, 50°, 55°, 60° and 65°C. and then inoculated into young cane or maize plants to test their infectivity. The results obtained are presented in Tables XIII and XIV.

TABLE XIII

Thermal-death-point determination of mosaic juices from various cane varieties representing thin indigenous reed canes, Saccharum officinarum and Coimbatore canes

Date of Inoculation	Mosaic juice treatment	Infectivity as tested on maize plants				
		Saretha	Co. 213	Co. 313	Red Mauritius	M. 16
28 June, 1935	Untreated control	+	+	+	+	+
	Heated at 40°C.	+	+	+	+	+
	Heated at 45°C.	+	—	+	+	+
	Heated at 50°C.	—	—	+	—	+

N.B.:—The sign + denotes positive infection and — denotes no infection of the inoculated maize plants.

TABLE XIV

Further thermal death point determinations with Saretha, *Co. 313 and M. 16 mosaic juice*

Date of inoculation	Inoculum	Test plants	Number of plants inoculated	Number infected
May, 1936	*Saretha* mosaic juice (untreated control)	*Saretha*	20	4
	Saretha mosaic juice heated at 42°C.	do.	20	4
	Saretha mosaic juice heated at 45°C.	do.	20	4
	Saretha mosaic juice heated at 50°C.	do.	20	1
April, 1937	Co. 313 mosaic juice (untreated control)	Co. 313	10	10
	Co. 313 mosaic juice heated at 60°C.	do.	10	0
	Co. 313 mosaic juice heated at 70°C.	do.	10	0
May, 1937	Co. 313 mosaic juice (untreated control)	do.	10	8
	Co. 313 mosaic juice heated at 50°C.	do.	10	4
	Co. 313 mosaic juice heated at 55°C.	do.	10	0
August, 1935	M. 16 mosaic juice (untreated control)	Maize	16	1
	M. 16 mosaic juice heated at 60°C.	do.	16	1

It will be seen that the thermal-death-point of Co. 213 mosaic virus lies at about 45°C. and that of *Saretha* mosaic virus a little over 50°C. Similar exposure at 50°C. does not destroy the viruses of M. 16 and Co. 313. Further heating at 55°C. inactivatived Co. 313 virus but the M. 16 virus retained some infective power even after exposure to 60°C. The fact that there are such wide differences (45-60°C.) in the thermal-death-point of mosaic leaf juices from different cane varieties strongly suggests the existence of at least three distinct sugarcane mosaic virus strains. A tentative classification of mosaic virus strains into strains X, Y and Z according to their thermal-death-point is suggested that is strain X with thermal-death-point between 60°C. and 70°C., strain Y between 50°C.-60°C. and strain Z between 40°-50°C.

It could however be argued that these differences in the thermal-death-point of the mosaic juices of different varieties are not due to the inherent properties of the virus strains but to the different colloidal action of the juices of the cane varieties used. To ascertain this point, Co. 313 mosaic virus was transmitted to healthy plants of Co. 213, Co. 313 and M. 16 by artificial inoculation and then tested for its thermal-death-point.

Mosaic leaf juices from plants of the three varieties of cane thus infected were exposed for ten minutes at 45°, 50° and 55°C. and then inoculated into maize and cane (*Surkha Saharanpuri*) plants to test their infectivity. The results obtained are given in Table XV.

TABLE XV

Thermal-death-point of Co. 313 mosaic virus after passage through other cane varieties

Mosaic juice treatment	Infectivity of Co. 313 mosaic after passage through					
	Co. 213		Co. 313		M. 16	
	Tested on		Tested on		Tested on	
	Maize	Cane	Maize	Cane	Maize	Cane
Untreated control	+	+	+	+	+	+
Heated at 45°C.	+	+	+	+	+	+
Heated at 50°C.	+	+	+	+	+	+
Heated at 55°C.	—	—	—	—	—	—

The sign + denotes successful infection and the sign — denotes no infection

It is evident from the above results that the thermal-death-point of the sugarcane mosaic virus does not change with a change of the cane variety but is a specific property of the strain.

The differences exhibited by the three sugarcane mosaic virus strains in longevity *in vitro* and dilution-end-point have already been referred to in the foregoing pages.

Besides these differences in the physical properties of the mosaic virus strains, there are marked differences in the phenomenon of recovery from mosaic in the canes affected with different mosaic virus strains. Setts from any portion of the cane affected with strain X or Y on planting give rise to clumps which are positively affected with mosaic. Further, in X type infection, all the shoots in the clumps show mosaic, with mosaic lesions even on the stem, while in Y type though mosaic infection on clump basis is almost 100 per cent, there are only about 70 per cent shoots that show mosaic symptoms. Recovery from mosaic to the extent of 40-50 per cent, on clump basis, has been observed in canes infected with strain Z of the virus.

Details of these experiments on the phenomenon of recovery from mosaic are being published in a separate paper.

This behaviour of recovery from mosaic of the diseased canes was reported by Brandes [1927], Lyon [1921], Stahl and Faris [1929], Tims *et al* [1935] and other workers. Kunkel [1924], however, working with 'noble' cane varieties in Hawaii reports absence of any such recovery from mosaic in D. 117.

Summers [1934] has described four types of mosaic on sugarcane in Louisiana and Tims, Mills and Edgerton [1935] mention two distinct types, the green type, common to Coimbatore varieties of canes, and the yellow type which resembles mosaic on Red Mauritius, M. 16, *surkha Saharanpuri*, etc. The differentiation of these types is based on the mosaic pattern produced by them on the cane plant.

In an experiment on inter-varietal transmission of sugarcane mosaic, the mosaic juices of Co. 213, 313, M. 16, Red Mauritius and *Saretha* were inoculated into each of the ten cane varieties under test, namely Co. 213, 210, 313, 416, 419, 420, B. 3412, *Lalgirah*, *Saretha* and P.O.J. 2878 and water-colour records of the pattern produced were made. It appeared from these records that Co. 213 and Co. 313 mosaic viruses (green type) on inoculation into *Lalgirah* (an indigenous cane) or B.3412 produced the pattern of yellow or Mauritius type, while on Co. 419 and the common Coimbatore canes they retained their original mosaic pattern. On Co. 420 and *Saretha* (another indigenous cane) a mosaic pattern intermediate between the two types (green and yellow) was produced. M. 16 retains its pattern on inoculation into B. 3412. These observations strongly suggest that the type or pattern of the mosaic produced depends, not on the virus but on the cane variety.

Similar results were obtained by Tims and Edgerton [1931] when the virus of yellow type of mosaic from C.P. 29/314 and C.P. 28/19 produced, on Co. 281, only the green type and the virus of green type from Co. 281 produced on C.P. 28/70 only the yellow type pattern.

During our six years' experience with mosaic affected varieties, variations observed in the type of mosaic pattern have been so great that it was not found possible to classify the various strains of sugarcane mosaic virus on this basis alone. The mosaic pattern was found to vary even in the same variety with climatic conditions such as temperature and humidity, soil conditions and age of the plant.

A few typical cases are reproduced in original colour (Plate I, figs. 1-6) which clearly point to the unreliability of mosaic mottling pattern as a basis for classification of mosaic virus strains.

Infectivity of sugarcane mosaic virus at different seasons of the year

Weather conditions seem to have a strong influence on successful inoculations in artificial transmission of sugarcane mosaic. Under Pusa conditions the months of May and June were found to be the most suitable period for successful inoculation when 100 per cent mosaic infection was obtained and the incubation period was as short as one week. In July the infection percentage usually fell to about 50 to 60, and August inoculations showed barely 10 to 15 per cent success with cane as test plants.

Similar seasonal influence was noticed at Delhi but the period of optimum infection is slightly earlier than that at Pusa. Inoculations made outside this favourable period of artificial transmission at Pusa were rarely successful under natural field conditions and were accompanied by a very prolonged incubation period. However, at Delhi, after the rainy season (July-August), when the weather warms up again and becomes hot and dry, during September and October, a definite increase in the number of successful inoculations was observed.

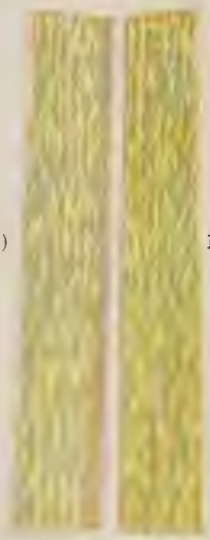
The summer of 1938 was exceptionally hot and dry for Delhi and a fair amount of successful infection was obtained even in July and August inoculations. On the other hand in 1939 the rains were particularly early and it was noticed that the artificial transmission experiments even during May and June were attended with much less success as compared with that of the previous years.

Results of various experiments carried out at Pusa and Delhi to ascertain the most favourable period for successful inoculation with mosaic juices of various cane varieties are given in Table XVI.

It is evident that the hot, dry period of the year is best suited for the successful artificial transmission of sugarcane mosaic ; also that while the months of May and June are the most suitable for Pusa, the period most suitable for Delhi, as judged by 1937 results, seems to be slightly earlier than that for Pusa.

In one experiment inoculations were made at different times of the day. Eighty young cane plants of Co. 313 growing in the field at Shahjahanpur Sugarcane Research Station, were inoculated on 30 April, 1937, with mosaic leaf juice of the same variety. Half of these were inoculated in the morning (8 a.m.) and the remaining 40 in the evening (5 p.m.). These gave 30 per cent and 80 per cent successful infection respectively ; only 12 plants out of the 40 inoculated in the morning developed mosaic infection whereas 34 plants showed infection in those inoculated in the evening.

FIG. (1)



Co. 213 on Co. 213

FIG. (2)

Co. 213 on Saretha

FIG. (3)

Co. 213 on Co. 420

FIGS. 1—3. Show the mosaic symptoms produced by Co. 213 mosaic juice on Co. 213, Saretha and Co. 420.

FIG. (4)

Co. 313 on Co. 313

FIG. (5)

Co. 313 on Saretha

FIG. (6)

Co. 313 on Co. 420

FIGS. 4—6. Show the mosaic symptoms produced by Co. 313 mosaic juice on Co. 313, Saretha and Co. 420.

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From this it would appear as if even the time of the day at which inoculations are made plays an important part in the successful transmission of the disease.

TABLE XVI

Seasonal influence on the artificial transmission of sugarcane mosaic virus

Locality	Inoculum	Date of inoculation	Number of plants inoculated	Number infected	*Incubation period (days)
Pusa	Co. 213 mosaic juice	22-4-36	20 (Co. 213)	4	14
	do.	16-5-36	20 „	6	7
	do.	9-6-36	20 „	20	7
	do.	16-6-36	20 „	5	21
	do.	3-7-36	20 „	4	21
	do.	29-7-36	20 „	3	21
Delhi	Co. 313 mosaic juice	November, 1936	10 „	2	91
	do.	January, 1937	12 „	3	35
	do.	February, 1937	10 „	1	21
	do.	March, 1937	10 „	8	14
	do.	April, 1937	10 „	10	14
	do.	May, 1937	10 „	10	7
	do.	June, 1937	10 „	8	11
	do.	July, 1937	10 „	2	15
Delhi	Co. 213 mosaic juice	14-5-38	10 (Maize)	9	9
	do.	4-6-38	6 „	6	7
	do.	23-6-38	10 „	5	7
	do.	7-7-38	10 „	2	15
Delhi	Co. 223 mosaic juice	22-1-38	10 „	0	..
	do.	6-5-38	10 „	5	4
	do.	11-7-38	10 „	1	7

* Incubation period is the number of days elapsing between inoculation and appearance of symptoms on the first plant

Experiments carried out to find the factors responsible for this seasonal variation on successful artificial transmission indicate that temperature plays the most important role. In one of these experiments 120 cane plants (Co. 313) were inoculated with Co. 313 mosaic leaf juice in November 1938, divided into three equal lots of forty each and placed in three glazed chambers greatly differing in their temperature. In chamber No. I, facing south, with a temperature variation of 25° to 40°C., the first case of mosaic appeared on the tenth day after inoculation and in two weeks time 35 per cent of the inoculated plants had developed mosaic. By the end of four weeks successful infection increased to 65 per cent and reached 90 per cent in the sixth week and 95 per cent at the close of the experiment (eighth week). In chamber No. II (20°C. to 34°C.) no mosaic infection was to be found in any of the inoculated plants till the end of the third week after inoculation ; by the end of sixth week only about 20 per cent of the inoculated plants developed mosaic symptoms and even at the close of the experiment (eighth week) infection was not higher than 35 per cent. In chamber No. III, facing north, and having the lowest range of temperature, 17°C. to 26°C., no case of mosaic developed even up to the end of six weeks of starting the experiment and by the eighth week only 10 per cent of the inoculated plants showed mosaic symptoms.

Results of the mosaic development in the above experiment along with temperature variation of the three chambers are shown in Table XVII.

TABLE XVII

Effect of temperature on artificial transmission of sugarcane mosaic

Chamber number	Temperature variation	Incidence and development of mosaic in the inoculated plants			
		2nd week	3rd week	6th week	8th week
I (Southern)	25°-40°C.	35 per cent	40 per cent	90 per cent	95 per cent
II (Central)	20°-34°C.	*nil*	*nil*	20 per cent	35 per cent
III (Northern)	17°-26°C.	*nil*	*nil*	*nil*	10 per cent

It is eveident from the above table that at a comparatively lower temperature (below 25°C.) successful infection is rather low and the incubation period is greatly prolonged, while at higher temperature (about 35°C.) successful infection is high and the incubation period is only about ten days, i.e., similar to the months of May and June which year after year have proved to be the most suitable months for obtaining successful artificial transmission. It would also be clear from the above data that the mosaic virus in the leaves of the cane plants even in November is as virulent as during the months of May and June and that the failure to obtain successful transmission under natural conditions during the cold weather is merely due to unfavourable environmental conditions.

INTER-VARIETAL TRANSMISSION OF SUGARCANE MOSAIC VIRUS

Mosaic leaf juice of five varieties, comprising the three main types of cane, the noble thick, the thin reed, and the medium thick Coimbatore canes were inoculated into ten canes of each of the ten selected varieties. The results of these inoculations are shown in Table XVIII.

TABLE XVIII

Inter-varietal transmission with mosaic juice of five varieties

Variety inoculated	Number of plants out of ten inoculated which showed infection after inoculation with mosaic juice from				
	Saretha (thin)	Co. 213 (medium)	Co. 313 (medium)	Red Mauritius (thick)	M. 16 (thick)
Co. 213	3	4	0	0	0
Co. 210	0	0	0	0	0
Co. 313	2	2	2	0	0
Co. 416	2	7	1	3	1
Co. 419	0	1	0	0	0
Co. 420	1	6	1	0	0
B. 3412	4	8	4	3	4
*Lalgirah**	1	4	3	1	0
Saretha	1	4	6	0	5
P.O.J. 2878	0	0	0	0	0

* This cane variety has not previously been observed to show mosaic

In subsequent experiments even some of those varieties which gave negative infection in the above table were successfully cross-inoculated particularly with Co. 213 and Co. 313 mosaic juice.

During 1935-36, mosaic juices of Co. 213, *Saretha*, Co. 313, Uba and M. 16 were inoculated into Co. 213 plants. In all cases except M. 16 typical mosaic mottling was produced with mosaic infection of 30 per cent, 20 per cent, 20 per cent and 10 per cent respectively.

In similar experiments, during 1936-37, at Delhi, M. 16 mosaic juice was successfully inoculated into Co. 213 and Co. 313 plants. In one of these experiments during 1938-39 even P.O.J. 2878, universally recognised as almost immune to mosaic, developed mosaic infection.

Furthermore, every year a large number of cane varieties that are inoculated with Co. 313 mosaic juice to test their varietal resistance develop mosaic infection, indicating thereby free and easy inter varietal transmission.

It is thus clear from the above that the sugarcane mosaic virus from one variety easily infects other cane varieties.

Transmission of sugarcane mosaic virus to other hosts

Of the various other graminaceous plants tested, maize (*Zea mays*), *jowar* (*Sorghum vulgare*) and *Euchlaena mexicana* have been successfully infected with sugarcane mosaic virus. Similar are the findings of Brandes and Klaphaak [1923] and various other workers. *Jowar* and maize plants, particularly the latter, take infection very readily and thus have proved very handy in various transmission experiments with sugarcane mosaic virus as they can be raised with much greater ease than cane plants. Moreover even during the months of July and August, when artificial transmission on cane plants becomes very difficult the maize plants give comparatively better infection and thus afford a longer working period with sugarcane mosaic virus. Maize plants growing in the field always showed quicker and better infection than those in the pots. At times the incubation period was as short as four days.

In one experiment, during 1937, mosaic-leaf juices of Co. 213, Co. 313, M. 16, B. 6308, *Saretha*, *Desi Ponda* (Shahabad) and *Lalgirah* were inoculated into maize and *jowar* plants in pots. The results with maize were rather disappointing but *jowar* plants took infection readily with the mosaic juice of all the seven varieties and produced typical mosaic symptoms. *Lalgirah* mosaic juice gave 100 per cent infection with an incubation period of only one week.

During 1938, mosaic juice of various cane, varieties, viz., Co. 213, 313, 223, 299, 419, *Surkha Saharanpuri*, M. 16 and P.O.J. 2878 had been inoculated into maize plants in different experiments. In all the cases the inoculated plants developed infection readily, producing typical mosaic symptoms.

In reverse inoculations, i.e., mosaic leaf juice of maize and *jowar* plants, artificially infected with sugarcane mosaic virus (Co. 213), inoculated into Co. 213 plants, both the miaze and *jowar* mosaic juices gave positive infection and freely produced typical mosaic mottling on the inoculated cane plants.

In Table XIX are given detailed results of some of these cross inoculation experiments.

TABLE XIX

Cross inoculation of sugarcane mosaic virus (nine cane varieties) to jowar *and maize and reverse transmission*

Date of inoculation	Source of mosaic juice used as inoculum	Test plant	Number of plants inoculated	Number infected
16 May, 1936	Co. 213	Cane (Co. 213)	20	6
	do.	*Jowar*	10	3
23 May, 1936	do.	Maize	30	27
	Saretha	do.	30	30
16 May, 1936	Co. 213	Co. 213	20	6
	Saretha	do.	10	2
	M. 16	do.	10	0
	Uba	do.	10	2
	Co. 213	do.	10	1
9 June, 1936	Co. 213	do.	20	20
	do.	Maize	8	8
	do.	*Jowar*	10	10
	Maize*	Co. 213	20	18
	do.	Maize	6	6
	do.	*Jowar*	8	1
	*Jowar**	Co. 213	20	11
	do.	Maize	6	0
	do.	*Jowar*	9	2
3 July, 1936	Co. 213	Co. 213	20	4
	do.	Maize	10	3
	do.	*Jowar*	10	3
4 July, 1036	Maize*	Co. 213	20	4
	do.	Maize	14	7
	do.	*Jowar*	18	8

TABLE XIX—*contd.*

Cross inoculation of sugarcane mosaic virus (nine cane varieties) to jowar *and maize and reverse transmission*—contd.

Date of inoculation	Source of mosaic juice used as inoculum	Test plant	Number of plants inoculated	Number infected
4 July 1936	*Jowar**	Co. 213	20	3
	do.	Maize	17	4
	do.	*Jowar*	19	9
7 May, 1937	M. 16 .	Co. 213	10	2
	do.	Co. 313	10	3
June, 1939	Co. 213	Co. 213	10	6
	do.	P.O.J. 2878	10	1
April, 1937	do.	Maize	16	6
	Co. 313	do.	16	10
	M. 16 .	do.	16	14
May, 1938	Co. 213	do.	10	9
	Co. 313	do.	10	9
	P.O.J. 2878	do.	10	2
	Co. 223	do.	10	5
	Co. 299	do.	10	7
	Co. 419	do.	10	5

* Maize and *jowar* plants artificially infected with Co. 213 mosaic juice

INTERACTION OF MOSAIC AND HEALTHY CANE JUICE

In experiments on inter-varietal transmission and varietal resistance it was noticed that though the mosaic virus from one variety could be successfully cross inoculated into other cane varieties, the percentage of infection would greatly vary from one variety to another. To test whether this differential resistance to infection was due to the presence of some special substances in the leaf tissue of resistant varieties which had inhibitory effect on the virulence of the mosaic virus, the mosaic juices of various cane varieties were mixed, in different proportions, with the healthy juices of the respective varieties as well as of other cane varieties, highly resistant as well as highly susceptible to mosaic, and then tested for their infectivity.

The mixtures of mosaic and healthy leaf juices of the same variety in the proportion of 1 : 10 failed to infect the test plants while the control (mosaic juice diluted with water 1 : 10) gave 60 per cent infection and the untreated, undiluted mosaic juice gave 100 per cent infection. Healthy leaf juice thus appears to have an inactivating effect on the mosaic virus. Further experiments were elaborated to determine the minimum proportions of the mixture of healthy and mosaic juices, which would just inactivate the mosaic virus. Such mixtures were allowed to interact for short (15 minutes) and long (40 hours at 6°C.) periods before these were tested for their infectivity. It was found that mosaic juice mixed with healthy in the proportion of 80 : 20 and 50 : 50 does retain some infectivity provided the period of interaction is short. The same mixture after 40 hours' interaction was found to be completely inactive.

Filter paper filtrate (amber colour) from healthy leaf juice has no such inactivating influence even after forty hours' interaction for different proportions tried (80 : 20, 50 : 50, 20 : 80).

During 1937-38, Co. 313 and M. 16 mosaic juices were mixed, separately, in varying porportions with healthy leaf juice of Co. 214 (a variety highly resistant to mosaic), allowed to interact for fifteen minutes and then inoculated into maize plants to test for inactivation. Table XX represents the results obtained.

TABLE XX

Interaction of Co. 313 and M. 16 mosaic juice with Co. 214 healthy juice

Proportions of mixture		Number of plants inoculated	Number infected
M. 16 (mosaic juice)	Co. 214 healthy juice	..	..
8·0 c.c.	0·0 c.c.	10	8
7·0 c.c.	1·0 c.c.	10	8
6·0 c.c.	2·0 c.c.	10	8
4·0 c.c.	4·0 c.c.	10	5
Co. 313 (mosaic juice)	Co. 214 (healthy juice)	..	..
10·0 c.c.	0·0c.c.	10	9
9·5 c.c.	0·5 c.c.	10	9
9·0 c.c.	1·0 c.c.	10	8
8·0 c.c.	2·0 c.c.	10	9

The experiment indicates that the healthy leaf juice of a different variety, even though resistant to mosaic, has no inactivating influence on mosaic leaf juice of Co. 313 and M. 16 when allowed to interect for 15 minutes in the proportions used.

During 1938-39, mosaic juices of Co. 213 and 313 were mixed in various proportions with the healthy juice of their respective variety as well as with that of various other cane varieties, highly resistant or highly susceptible to mosaic, were allowed to interact for varying lengths of time, and were then tested for their infectivity. It was found that the mosaic juice when mixed with the healthy juice of the same variety and allowed to interact for 40 hours showed distinct decrease in its virulence but no such inhibitory effect was seen when it was mixed with the healthy juices of other cane varieties whether susceptible or resistant to mosaic.

No loss of infection is reported by Matz [1933] when infectious green foliage juice was diluted with an equal volume of healthy green foliage juice. Presumably the time of interaction was short as duration of contact has not been mentioned.

Seed transmission of sugarcane mosaic virus

Cane. Selfed seed of Co. 313 affected with mosaic was very kindly produced, on our request, by the Sugarcane Specialist, Bihar. Seedlings numbering about 100 raised from such fluff at the Sugarcane Research Station, Musheri (Bihar), were examined from time to time and were found absolutely free from mosaic throughout the season.

Maize. Maize plants artificially infected with sugarcane mosaic virus (Co. 213 and Co. 313) during 1936-39 were allowed to set seed. A large number of plants raised from such maize seed during 1935-36 at Pusa and during 1936-37, 1937-38 and 1938-39 at Delhi, were carefully observed throughout the growing period and were found to remain absolutely free from any mosaic symptoms. Some of these seeds have been tested for three generations successively.

It is indicated from these experiments that the sugarcane mosaic virus is not seed transmissible.

Reaction to chemicals

In an earlier communication Rafay [1935] dealt in some detail with the effect of certain chemicals on the infectivity of sugarcane mosaic virus.

Subsequently to the above communication the effect of certain other chemicals has been tested on sugarcane mosaic virus. Co. 213 mosaic leaf juice was treated for fifteen minutes with 10 per cent and 20 per cent alcohol, 5 per cent toluene, chloroform vapour, carbolic acid one per cent, and formaldehyde one per cent, and then tested for infectivity. With the exception of the last two the infective principle of the mosaic juice did not show any signs of inactivation.

Effect of mosaic on chlorophyll contents of cane leaves

The estimations of cholorophyll were carried out by extracting equal areas of mosaic and healthy leaves in 85 per cent alcohol by gently warming it. Equal areas of leaves were removed by punching out leaf-lamina tissue from the leaves of the same age and growth. The amounts extracted were compared in the Dubosque calorimeter by Plunger method. Determinations of chlorophyll made in June showed that on the axerages daly affected leaves (Co. 213) contained 20 per cent

less chlorophyll than the healthy. The comparative distribution of chlorophyll, leaf by leaf, in Co. 213 healthy and mosaic affected plants is given below :

1st leaf (fully open)	47 per cent	of similar healthy leaf
2nd „	75 per cent	do.
3rd „	84 per cent	do.
4th „	95 per cent	do.

In another experiment the relative amounts of chlorophyll in the leaves of healthy and mosaic affected plants were determined at different times of the year in two sugarcane varieties, viz., Co. 213 and *Saretha*. The relative percentage of chlorophyll of mosaic leaves as compared to healthy leaves is given in Table XXI.

TABLE XXI

Chlorophyll contents of leaves of healthy and mosaic affected cane plants (Co. 21 and Saretha) *at different times of the year*

Saretha		Co. 213	
Date of estimation	Relative per cent chlorophyll (mosaic : healthy)	Date of estimation	Relative per cent chlorophyll (mosaic : healthy)
13 July	69·7	28 July	69·7
4 August	74·8	11 August	78·1
5 September	86·1	30 August	80·6
20 September	93·4	15 September	78·0
17 October	97·4	16 October	71·8
27 November	95·2	24 November	86·1

Leaf to leaf variation of chlorophyll in mosaic and healthy leaves followed the same course. The topmost leaves were very poor in chlorophyll. Old, dying leaves also contained little chlorophyll, the fourth and the fifth leaf had the highest amount of chlorophyll. The difference in the amount of chlorophyll in mosaic as compared to healthy leaves was most marked in the fourth leaf in Co. 213 and in the third leaf in *Saretha*.

It is clear from the above data that the adverse effects of sugarcane mosaic virus on the chlorophyll content of affected plants is of a very limited duration and that the plants recovered from the bad effects of mosaic and regenerated chlorophyll with the onset of the monsoon. Thus the effect of mosaic infection on yield is limited as the

period of reduced photosynthetic activities of affected plants is not very long. This perhaps explains why reduction in yield as a result of mosaic infection under conditions as obtained in Northern India is not so great as in some other tropical countries. As climatic conditions such as temperature, humidity, sunshine, etc., greatly affect the regeneration of chlorophyll in the leaves, the prevailing weather conditions seem to exercise considerable influence on the amount of damage done by mosaic. This would probably explain the variations in the loss of tonnage through mosaic disease at different places and from year to year even in the same locality.

Mosaic virus in the old cane leaves

It is usually noticed that the mosaic symptoms on affected cane plants are confined only to a few young leaves of the crown. The old leaves below, previously forming the crown and exhibiting prominent mosaic markings, are usually without any mosaic mottling. To study whether such leaves were really free from mosaic virus, the oldest uniformaly green leaves were collected from mosaic affected canes (Co. 313, six months old crop) and their juice tested for infectivity and compared with that of young leaves from the same canes showing mosaic markings prominently. It was found, with Co. 313 as test plants, that in three weeks' time the old leaves gave 20 per cent successful inoculations while the mosaic juice from young leaves produced 100 per cent infection. It is evident that the old leaves of mosaic affected canes, though devoid of mosaic symptoms, contain active mosaic virus, indicating thereby that it is only a case of masking of the mosaic symptoms. However, the comparatively longer incubation period of infection of the virus from old leaves and lower percentage of successful infections obtained indicate that the virulence of the virus in old leaves is greatly impaired.

Discussion

For a long time investigators failed to infect plants experimentally with sugarcane mosaic virus and they were, thus, very sceptical whether to regard this disease of sugarcane as infectious or ascribe it to inherent degeneration of cane or to some non-parasitic disease. The truly infectious nature of sugarcane mosaic virus was first established by Brandes [1920], and subsequently confirmed by Brandes and Klaphaak [1923], Bruner [1922], McRae and Subramaniam [1928], Sein [1930]. Successful infection had been obtained by Earle [1919], Matz [1919] and Lyon [1921]. All these workers experienced great difficulty in obtaining successful transmission of mosaic with expressed juice. Infection in the inoculated plants was invariably low and at times the inoculations failed completely. Inactivation of the mosaic virus in the extracted juice was ascribed to the action of air by the earlier workers and great emphasis was, therefore, laid on extraction of the juice under a cover of mineral oil to preclude oxidation. Bruner [1922] showed that the diseased cane juice extracted without any provisions against oxidation reproduced the disease just as the juice extracted under a protective cover if there is no delay in making the inoculation after extracting the juice. Matz [1933] emphasised that it was the method of inoculation that was chiefly at fault for these failures.

With his new method (described in the previous pages) he demonstrated that where fresh or properly stored juice was used high percentage of infection generally resulted, although the juice was never protected from the air.

In the present investigation, it has been shown that even with the new method of Matz [1933] successful inoculations could be obtained only in certain months of the year namely May and June. Inoculations made outside this period of successful infection either failed or gave low percentage of infection with a prolonged incubation period. The months of May and June under Northern India conditions are characterised by exceedingly hot and dry weather. During July and August the temperature is not much lower than that prevailing in May and June, but owing to rainy weather, the humidity is very much higher and this factor presumably interferes with successful infection. This hypothesis is further supported by the observations that during 1938, which was a comparatively hot and dry summer, with rainfall much below the normal, distinctly higher successful infection was obtained even during the months of July and August. On the other hand the rains set in early during 1939 summer and the inoculations made even during May and June met with poor success. Failure of infection during the winter months, in spite of the humidity being at a low level, has been clearly demonstrated to be due to unfavourable temperature. By raising the temperature to the neighbourhood of 30-35°C. highly successful infections were obtained. It would be thus clear that successful artificial transmission of sugarcane mosaic virus with expressed juice requires a very exacting range of external condition of temperature, humidity, sunshine, etc. Most of these factors are highly variable and in this presumably lies the explanation of the variations in the results of sugarcane mosaic transmission by different workers and the difficulty experienced in obtaining successful inoculations.

Another point that does not seem to have been realised, till very recently, is the existence of different sugarcane mosaic virus strains. It is quite likely that different workers may have been working with different strains and the results would naturally vary. The results put forth in this paper clearly establish the existence of three sugarcane mosaic virus strains.

There are four fundamental factors for determining the existence of strains of a virus ; namely, dilution-end-point, thermal-death-point, resistance to ageing and resistance to alcohol. The first three have been determined satisfactorily for mosaic affected cane material from different cane varieties but the last mentioned could not be tested properly as sugarcane mosaic virus is sensitive even to low concentrations of alcohol. The results obtained with these experiments clearly point to the presence of at least *three* sugarcane mosaic virus strains in India, which retain their specific physical properties even after passage through other cane varieties.

The Indian sugarcane mosaic virus strains have been tentatively termed *Saccharum mosaic virus* X, Y and Z. Smith [1937] has classified the sugarcane mosaic virus strains as *Saccharum virus* 1B, 1C, 1D and 1E of Summers and *Saccharum virus* 1F of Tims. Only after a comparative study of these five strains with the three Indian strains for their physical properties it will be possible to deter-

mine their identity. As judged from the symptom picture the Indian sugarcane mosaic virus strains resemble *Saccharum virus* 1B of Summers.

The results presented in the present paper also show that the general surmise regarding the inactivation of the sugarcane mosaic virus in the expressed juice due to oxidation is erroneous. Successful infections have been generally obtained with the juice extracted without taking any precaution against air coming into contact with it. Even the mosaic juice treated with hydrogen peroxide, a strong oxidising agent, has proved infectious. Successful infection has also been obtained with the expressed juice stored for several days, without the exclusion of air, provided the storage temperature is low enough. These results are in accordance with those of Matz [1933]. Sugarcane mosaic virus is relatively unstable *in vitro* and temperature is the most important factor in determining its longevity. The success of inoculations obviously would be affected by the temperature reached in crushing of the mosaic cane material and extraction of the mosaic juice. All these operations should be conducted at as low a temperature as possible, using ice cold water for grinding the material to ensure inoculum of high infectivity.

Summary

Three strains (X, Y and Z) of sugarcane mosaic virus with marked differences in their physical properties are distinguished. Their thermal-death-point ranges from 45° to 65°C. The thermal death-point of strain X in expressed juice is 65°C., that of Y, 55°C. These two strains can stand a dilution of 1: 100 and can remain viable for six hours at 30°-32°C. The thermal-death-point of Z strain is 45°C. and it can stand a dilution of 1 : 50 only and scarcely survives for two hours at 30°-32°C.

The three strains of sugarcane mosaic virus are not filterable through a Chamberland L_3, Berkfeld (V), or Seitz filter. Even ordinary filter paper filtrate (amber colour) is non-infectious.

The mosaic virus can be centrifuged for half an hour at 3,000 revolutions per minute without any appreciable loss of virulence ; further centrifuging impairs its infectivity.

Sugarcane mosaic virus *in vitro* is relatively unstable. It loses viability within a few hours at room temperature (30°-32°C.). But at ower temperature (5°C. to 6°C.) the virus can remain viable for 8 days in the extracted juice. Mosaic affected leaves stored at 5°-6°C. retain active mosaic virus even after 15 days, storage.

Storage temperature is the most important factor in the longevity *in vitro* of sugarcane mosaic virus.

The optimum temperature for artificial transmission of mosaic is about 32°C.-35°C.

The type of pattern of the mosaic produced on leaves is greatly influenced by the cane variety and seasonal variations which, therefore, cannot be used reliably for the purposes of classification of the sugarcane mosaic virus strains.

Weather conditions have a strong influence on successful inoculations in artificial transmission of sugarcane mosaic ; the hot dry summer months of May and June being most suitable. Temperature is the most important factor.

The sugarcane mosaic virus from one cane variety easily infects other cane varieties as also maize (*Zea mays*) and *jowar* (*Sorghum vulgare*). The virus after passage through maize and *jowar* still remains virulent on cane.

Sugarcane mosaic virus is not seed transmissible. The reaction of sugarcane mosaic virus to alcohol, toluene, carbolic acid, formaldehyde and chloroform vapour was tested. The virus is rather sensitive to even weak concentrations of alcohol.

Mosaic juices of Co. 213, 313 and M. 16 when mixed with the healthy juice of the same variety and allowed to interact for some length of time showed a distinct decrease in virulence but no such inhibitory effect is seen with the healthy juice of other cane varieties whether susceptible or resistant to mosaic.

Mosaic affected leaves, on an average, have 20 per cent less chlorophyll than corresponding healthy leaves in June, but from monsoon onwards the differences in chlorophyll contents decrease until by October both the mosaic and healthy leaves have practically the same amounts of chlorophyll.

The old leaves of mosaic affected plants from which mosaic symptoms have totally disappeared contain fairly viable mosaic virus within them, indicating thereby that it is merely a case of masking of the mosaic symptoms.

The age of the plant has no effect on the virulence of the virus. The young leaves of mosaic affected old plants even late in the season in November and December have been found to contain mosaic virus in as virulent a form as during May and June. Failure of artificial transmission in colder months is merely due to the absence of environmental conditions suitable for mosaic development.

Acknowledgment

Thanks are due to Mr. L. D. Galloway and Dr. G. Watts Padwick, Imperial Mycologist, for their keen interest and helpful suggestions during this work and to the Imperial Council of Agricultural Research for financing this scheme of investigation. Also to Messrs. K. M. Dutt and G. K. Roy, Fieldmen in the Scheme, for general help and assistance in growing of the plants and inoculations thereof.

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STUDIES ON THE SUGARCANE DISEASES IN INDIA

II. THE PHENOMENA OF NATURAL TRANSMISSION AND RECOVERY FROM MOSAIC OF SUGARCANE

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(Received for publication on 7 January 1942)

In our experiments at Pusa with a cane variety, Co. 213, to study the effect of sugarcane mosaic on yield and quality of juice, where cane material from healthy and mosaic-affected clumps was planted in adjacent plots, it was always found that some of the plants in the mosaic-plots, though they originated from setts from mosaic-affected clumps, were not showing symptoms of mosaic; some of the plants were similar in appearance to normal healthy ones.

In 1933, 100 cane plants of Co. 213 showing mosaic symptoms from the very beginning of the season were marked for the purposes of recognition. These were harvested in February 1934, cut into setts and planted for 1934-35 cane season to study the phenomenon of recovery from mosaic. Careful observations throughout the season revealed that only about 40 per cent of the shoots exhibited mosaic symptoms, the remaining 60 per cent being absolutely free from mosaic mottling.

The experiment was repeated in 1935-36 season and the results obtained were similar to those obtained during the previous year, there being only 38 per cent shoots affected with mosaic, thus showing a recovery of about 60 per cent.

In the above experiment during 1935-36 two other cane-varieties, namely, *Saretha* (a thin indigenous reed cane) and Co. 313, a Coimbatore cane variety were also included in this test and it was found that *Saretha* showed 83 per cent mosaic affected shoots and Co. 313 had 55 per cent of its shoots affected.

This experiment when repeated in the summer of 1936 gave similar results, i.e. Co. 213 showed the greatest amount of recovery and *Saretha* the least, while Co. 313 occupied an intermediate position, indicating thereby that the amount of recovery from mosaic in sugarcane varies with the cane variety.

This fact was confirmed when yield trials conducted during 1936-37 at Karnal with a thick cane variety, locally known as *Surkha Saharanpuri* a noble cane of *Saccharum officinarum* type, revealed that no recovery from mosaic could be observed. All the plants in mosaic-plots showed definite mosaic symptoms. During 1937-38,

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a certain amount of recovery from mosaic (about 16 per cent) in *Surkha Saharanpuri* was observed at Karnal, but it might be mentioned that 1937-38 was a year highly unfavourable to the cane crop in the Western United Provinces and Eastern Punjab where it failed to ripen. During 1938-39, which was a normal year at Karnal regarding cane growth, no recovery from mosaic in *Surkha Saharanpuri* was observed.

Yield trial experiments with Co. 313 at Shahjahanpur (United Provinces) with locally selected mosaic material also revealed total absence of recovery from mosaic during 1937-38. This was unexpected as Co. 313 variety had always been observed to give at Pusa a certain amount of recovery from mosaic. The fact that the same cane-variety was reacting so differently at two different localities regarding recovery from mosaic, was suggestive of the role of soil and climatic conditions in recovery. To test this hypothesis, in 1938 Co. 313 mosaic affected material from Shahjahanpur was planted at Pusa, Gorakhpur, Shahjahanpur, Nagina, Muzaffarnagar, Delhi and Karnal (100 canes at each place) and Co. 313 mosaic-affected cane from Pusa was planted at Pusa, Delhi and Karnal and observed for the phenomenon of recovery. These places are situated at widely separated points in four different provinces in Northern India and have great variations in their soil types and climatic conditions. The results obtained showed that while Co. 313 mosaic-affected material from Pusa gave 10-20 per cent recovery from mosaic at Delhi, Karnal and Pusa, no recovery was observed in Co. 313 Shahjahanpur material at any of the places.

The experiment was repeated during 1939-40 season with Co. 313 mosaic-affected material from Pusa and Shahjahanpur at all the above localities. The results obtained confirmed the previous findings that Co. 313 Shahjahanpur (United Provinces) material did not show any recovery from mosaic at any of the places tested while Co. 313 material from Pusa (Bihar) gave a certain amount of recovery at all the places except Delhi. The amount of recovery varies from place to place. It might be mentioned that the recovery, on the whole, during the season (1939-40) was lower than the previous years, and at Delhi while Co. 313 (Pusa) gave ten per cent recovery in 1938-39, no recovery was observed in 1939-40 in the same material. Recovery figures for Karnal and Shahjahanpur in the latter year are also rather low. Detailed information regarding recovery from mosaic in Co. 313 affected with mosaic from Shahjahanpur and Pusa during 1939-40 is presented in Table I.

There are three points clearly brought out by these experiments :

(i) In all experiments, there is total absence of recovery from mosaic in Co. 313 material from Shahjahanpur at any of the places tested, while Co. 313 (Pusa material) shows an appreciable amount of recovery at all these places.

(ii) The amount of recovery in the same material varies from place to place (Delhi 10 per cent, Pusa 20 per cent) indicating thereby the role of soil conditions.

(iii) Variation in recovery at the same place in the same cane material from year to year suggests the effect of seasonal influence.

The same cane variety (Co. 313) from two different localities, Pusa and Shahjahanpur, behaving so differently, strongly suggests that the mosaic virus strain affecting Co. 313 at Shahjahanpur is different from the Pusa strain. This view is

TABLE I

Recovery from mosaic of Co. 313 (Shahjahanpur) and Co. 313 (Pusa) during 1939-40 at seven localities in North India

Locality	Co. 313 (Shahjahanpur)					Co. 313 (Pusa)				
	Total number of clumps	Number of healthy clumps				Total number of clumps	Number of healthy clumps			
		May	June	August	February		May	June	August	February
Pusa	235	5	Observations not made	0	0	250	50	Observations not made	8	8
Gorakhpur	796	34	do.	0	0	603	306	do.	108	58
Shahjahanpur	776	0	do.	0	0	276	19	do.	5	Observations not made
Nagina	464	15	do.	0	Observations not made	227	83	do.	50	do.
Muzaffarnagar	556	29	0	0	do.	420	204	83	83	do.
Delhi	300	0	0	0	0	283	0	0	0	0
Karnal	357	0	0	0	0	445	14	10	5	5

strongly supported by the fact that the thermal-death-point studies with mosaic leaf juices of different cane varieties have shown a wide range of variation (45°C-65°C.) indicating the existence of more than one strain of sugarcane mosaic virus in India. It has also been determined that the thermal-death-point of Co. 313 mosaic virus remains constant even after passage through other cane varieties. Experiments with Co. 313 material from Shahjahanpur and Pusa have revealed a difference of about 7°C. in the thermal-death-point of the two.

A certain amount of recovery from mosaic has been observed in Co. 223, 299, and 419, artificially infected with Co. 313 (Pusa) mosaic virus.

Mosaic-affected cane material of the following varieties from different localities was collected and multiplied during 1938-39 and tested for recovery from mosaic during 1939-40 at Delhi.

Punjab

Karnal	*Surkha Saharanpuri*
Gurdaspur	Co. 223, 285, 312, and P.O.J. 2878
Lyallpur	Co. 313, 391, and 514
Risalewala (Lyallpur)	Co. 223, 313, and P.O.J. 2878
Jullundur	Co. 313

United Provinces

Muzaffarnagar	Co. 312
Shahjahanpur	Co. 313
Meerut	B 6308

With the exception of Co. 285 and Co. 312 from Gurdaspur that showed 7 per cent and 13 per cent recovery respectively, none of the other 13 collections showed any recovery from disease. Presumably these were affected with some mosaic virus strain similar to that of Co. 313 (Shahjahanpur).

A similar phenomenon of recovery from mosaic in sugarcane has been reported by Lyon [1921], Kunkel [1924], Brandes [1927], Barber [1928], Stahl and Faris [1929] and Tims, Mills and Edgerton [1935].

All the setts from mosaic affected canes not giving rise to mosaic-affected plants obviously points to the uneven distribution of the mosaic virus within the cane. To determine the relative mosaic infestation of the various portions of the cane stem 100 cane plants, showing mosaic symptoms throughout the growing season, of Co. 213, 313, 312, 285 and *Surkha Saharanpuri* were selected and cut into 3-eye setts. Setts from different portions of the stem, S_1 (top), S_2, S_3, S_4 and S_5 (bottom) were planted separately in five rows and were observed for their germination and mosaic development. Germination was greatest in the top setts and poorest in the bottom ones, but comparatively greater amount of recovery was observed in the plants originating from the setts from the middle (S_3, S_4) portions than the top (S_1, S_2) or the bottom (S_5) portions of the cane. Actual figures of these recoveries are given in Table II.

TABLE II

Distribution of mosaic virus within the affected canes

Position of setts	Recovery from mosaic (per cent)				
	Co. 213 (Pusa) 1934-35	Co. 313 (Pusa) 1938-39	Co. 312 (Gurdaspur) 1939-40	Co. 285 (Gurdaspur) 1939-40	*Surkha Saharanpuri* 1937-38
S_1 (top)	55	13	0	0	13·8
S_2	67	2	5	7	13·5
S_3	76	9	14	5·5	14·5
S_4	70	17	27	9·5	20·0
S_5 (bottom)	58	8	28	8	24·5

These healthy plants of Co. 213, 313, 223, 299 and 419 obtained by recovery from mosaic-affected setts have been tested for latent infection of mosaic virus by inoculating the juice from the young central leaves of these plants into young cane and maize plants throughout the season (1937-38) but there was no development of mosaic symptoms in any of the inoculated cane or maize test plants, while the corresponding controls, inoculated with mosaic leaf juice of the respective varieties, showed the usual normal infection. It may, therefore, be safely concluded that these 'recovered' plants are free from any latent infection and that they are by no means 'carriers' with masked mosaic symptoms. It is a case of true recovery from mosaic.

Plants grown from the recovered canes of Co. 223, 299 and 419 and inoculated during the season (1939-40) with the respective mosaic leaf juice developed typical mosaic symptoms showing thereby that the recovered plants were not immune to sugarcane mosaic and were capable of re-infection with cane mosaic virus.

NATURAL TRANSMISSION

Spread of sugarcane mosaic from plant to plant in nature, presumably through the agency of insects, does occur in India but only in restricted localities. Coimbatore (South India) was the first place in India where natural transmission was observed. Subsequent search for this natural spread of mosaic disease in cane revealed its existence at a few other centres as well in the South, but it was never observed to occur in Bihar. For a considerable time it has been the general belief of those interested in sugarcane in India that natural transmission of sugarcane mosaic was confined to South India and it did not exist in North India above the Vindhiachal range of mountains.

At Pusa during 1932-33 and 1933-34, 43 cane varieties were grown in rows alternating with Co. 213 mosaic affected rows. No case of mosaic infection was observed throughout the growing season in the rows grown from healthy setts, with the exception of a single solitary clump each in Co. 301 and *Saretha* and 3 clumps in Co. 313. This clearly indicated that natural transmission of mosaic under Pusa conditions is practically non-existent.

Absence of any secondary infection in healthy plots in yield-test experiments extending over five successive seasons at Pusa where mosaic and healthy plants were growing in adjacent plots also lend strong support to the view that natural transmission of mosaic does not occur at Pusa.

Yield trial experiments to study the effect of mosaic on Co. 313 at Shahjahanpur (United Provinces) for three seasons (1937-38, 1938-39 and 1939-40) and at Karnal (Punjab) on *Surkha Saharanpuri* for three seasons (1936-37, 1937-38 and 1938-39) also revealed that there was little natural spread of the disease from mosaic-infected plots to healthy plots in spite of their close proximity.

To study more thoroughly the existence or otherwise of natural spread of mosaic in Northern India, the chief sugarcane tract of the country, healthy material of Co. 313, a cane variety highly susceptible to mosaic, was planted during (1938-39 and 1939-40) cane seasons, alternating with mosaic-affected material of the same variety at several localities situated in four provinces in Northern India, namely, Pusa, Gorakhpur, Shahjahanpur, Muzaffarnagar, Nagina, Delhi and Karnal. Three or four observations were made during the season and the results obtained show that there was no evidence of any natural spread whatsoever at Pusa or Delhi, that at Nagina, Karnal and Shahjahanpur there was about three to five per cent natural infection while Gorakhpur and Muzaffarnagar results revealed the occurrence of active natural transmission. The occurrence of natural transmission in an active form at Gorakhpur is rather interesting as this place has soil and climatic conditions similar to north Bihar where natural transmission, as observed at Pusa, does not exist. Results of these experiments are presented in Tables III and IV.

TABLE III

Natural transmission of mosaic during 1938-39 at seven localities in North India

Date of observation	Incidence of secondary infection in healthy rows (per cent)						
	Karnal	Delhi	Muzaffar-nagar	Nagina	Shahjahan-pur	Gorakh-pur	Pusa
May, 1938	3	0	Not observed	Not observed	Not observed	Not observed	Not observed
July, 1938	5	0	do.	do.	do.	do.	do.
August, 1938	5	0	8	0	2	6	0
October, 1938	5	0	25·5	3·8	Not observed	18	0
February, 1939	5	0	39	5 8	4	19	0

TABLE IV

Natural transmission of mosaic during 1939-40 at six localities in North India

Locality	Cane variety	Incidence of secondary spread of mosaic								
		Total number of clumps in healthy rows	Number showing mosaic				Percentage secondary infection			
			May	June	August	February	May	June	August	February
Pusa	Co. 313	250	0	Not observed	0	0	0	..	0	0
Gorakhpur	Co. 313	902	40	do.	158	182	4·4	..	17·7	20·2
Shahjahanpur	Co. 313	672	0	do.	74	Not observed	0	..	11·1	..
Nagina	Co. 313	435	0	do.	12	do.	0	..	2·8	..
Muzaffarnagar	Co. 313	690	4	10	10	do.	0·6	1·5	1·5	..
Karnal	Co. 313	442	22	30	146	123	5	6·8	32·5	27·8
Karnal	*Surkha Saharanpuri*	339	5	6	16	19	1·5	1·5	4·6	5·4

At Delhi there have been growing side by side, for the past three seasons, healthy and mosaic plants of nearly 30 cane varieties in our collection but no case of secondary infection has so far been observed.

At Karnal in addition to the experiments described above, a slight amount of natural transmission has been noticed in our varietal plots, where a large number of cane varieties is grown to raise necessary material for our inoculation experiments. During 1939-40, though *Surkha Saharanpuri* showed the usual 4 to 5 per cent secondary infection a considerable amount of natural transmission of mosaic was observed in Co. 313.

Other places in Northern India where natural transmission has been seen are Gurdaspur, Jullundur and Lyallpur in the Punjab as reported by Luthra and Sattar [1935] and observed also by the senior author during the past three seasons.

Natural spread of mosaic is fairly active at Gurdaspur and Jullundur but exists only to a moderate extent at Lyallpur.

It will be seen from the above that active natural transmission occurs only at a few restricted places in the Northern India cane tract, namely, Gorakhpur and Muzaffarnagar in United Provinces, and Gurdaspur, Karnal and Jullundur in the Punjab ; at other places natural transmission is either absent or present only to a very slight extent. A glance at the map of India will show that these regions of active natural transmission are not continuous and that all these places, lie mostly in the submontane tract, near the foot of the hills, where the summer temperature is comparatively mild. Furthermore, most of the secondary spread takes place during or soon after the rainy weather when the insects are most numerous and at the height of their activity in India.

Aphis maidis, universally recognized since 1920 [Brandes, 1920] as the chief insect vector of sugarcane mosaic, exists in India and so does another less important vector, *Toxoptera graminum*, reported by Ingraham and Summers [1938], but the insect vector of sugarcane mosaic virus in India remains, as yet, undetermined.

Indirect evidence on the prevalence of *A. maidis* in large numbers on *sorghum* and maize at places like Coimbatore and Gurdaspur where active natural transmission takes place and the occurrence of natural spread of mosaic in sugarcane crop at the time of or subsequent to the period of optimal activity of *A. maidis* certainly points to the possibility of *A. maidis* being the vector of sugarcane mosaic in India. On the other hand, *A. maidis* and *Toxoptera graminum* have been found in plenty during 1938-39 and 1939-40 seasons at Delhi, on maize, *sorghum* and barley crops growing quite close to our sugarcane plot consisting of over 30 cane varieties, both healthy and mosaic-affected growing side by side, but no case of secondary infection of mosaic in any of the varieties has been observed.

During November 1938, a few plants of *Shakarchinya* cane variety (an indigenous thin reed cane) *growing in the field* at Delhi were found to be infested with *Aphis maidis*. No other cane variety in the collection had any trace of aphids on it. This observation is by itself of considerable interest as *Aphis maidis*, though a well recognised vector of sugarcane mosaic, seldom colonises on cane.

Artificial insect transmission experiments

Various attempts to make *A. maidis* from *sorghum* colonise on healthy and mosaic-affected sugarcane varieties, including Co. 223, 312 and 313 (varieties highly susceptible to mosaic), resulted in failure, though the aphids freely colonised on the control *sorghum* plants under the experimental conditions.

Similar attempts with *A. maidis* from the variety *Shakarchinya* met with the same fate, i.e. no colonisation of aphids was observed on any cane variety except *Shakarchinya*.

Barley aphids, similarly treated, failed to colonise on Co. 223, 312 and 313, while slight colonisation was observed on *Shakarchinya* and *Saretha* (also an indigenous thin reed cane) plants.

In all these insect transmission experiments it was observed that, although *A. maidis* from different sources (*sorghum*, *Shakarchinya* and barley) did not colonise on cane, the winged aphids were found crawling up and down, and at times resting on the cane leaves.

In another experiment barley and *sorghum* plants badly infested with aphids were caged together with healthy and mosaic-affected cane plants of various varieties for about one week. The plants were then watched for mosaic development. Aphids were found freely crawling about on the cane plants. While no case of mosaic was observed in any of the cane plants, two *sorghum* plants developed typical mosaic symptoms indicating thereby the possibility of transmission of mosaic disease to these *sorghum* plants by the aphids after casually feeding on mosaic-affected cane plants.

A similar phenomenon was observed during one of the visits to Gurdaspur during the first week of September 1938 where it was found that in a *sorghum* field infested with aphids adjoining the ratoon cane crop, showing 100 mosaic infection, almost all the *sorghum* plants towards the end of the field nearest to the ratoon cane were affected with mosaic and the infection gradually decreased as one walked away towards the other end (farthest from ratoon cane plot) of the *sorghum* field. No aphids were found colonising on any of the five cane varieties in the ratoon crop. Possibly casual visits and feeding of the aphids on the mosaic-affected cane plants and then feeding on *sorghum* plants may have resulted in this mosaic infection of the *sorghum* crop.

Various attempts previously made at Pusa to effect transmission of sugarcane mosaic virus by *A. maidis* had met with failure.

It may be argued that at Pusa and Delhi where natural transmission does not take place, there may be operating some factor, possibly temperature or humidity, affecting the ability of *A. maidis* in effecting the natural spread of mosaic, but the repeated failure of *A. maidis* reported by the Mycologist, Madras Government, to transmit sugarcane mosaic under controlled conditions, at Coimbatore at a time when active natural transmission is in evidence out in the fields throws doubt on *A. maidis* being the chief vector of sugarcane mosaic virus in India.

The small amount of natural transmission is perhaps well counterbalanced by the phenomenon of recovery so that the actual rate of increase of mosaic in Northern

India crop need not necessarily be great in certain varieties, provided the initial planting cane material is not from a heavily mosaic-infected crop.

Summary

All the setts (cuttings) from mosaic-affected canes do not give rise to plants affected with mosaic. Some of the plants show no mosaic symptoms and are entirely free from latent mosaic infection.

The amount of recovery varies with the variety. It also varies from place to place and year to year even with the same variety, indicating thereby the role of soil and climatic conditions.

Mosaic material of the same cane variety from different localities may show great variation in the amount of recovery suggesting thereby the existence of more than one mosaic virus strain in India.

Natural transmission is either absent in Northern India, or occurs only to a slight extent, with the exception of a few restricted localities in submontane tracts.

The insect vector of sugarcane mosaic in India remains undetermined so far and it is possible that it may prove to be other than *Aphis maidis*, the universally recognised vector of sugarcane mosaic disease. *Aphis maidis* is, however, fairly widespread in India.

Acknowledgments

Thanks are due to Mr. L. D. Galloway and Dr. G. Watts Padwick, Imperial Mycologist, for their keen interest and helpful suggestions in this work and to the Imperial Council of Agricultural Research for financing this Scheme. Thanks are also due to the Provincial Officers of the Department of Agriculure, United Provinces and Bihar for providing the necessary facilities for conducting these experiments and to Mr. G. K. Roy, Fieldman, in the Scheme, for general help and assistance particularly in the field work.

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SYSTEMATIC POSITION OF *CHILO ZONELLUS* SWINHOE AND CHAETOTAXY OF ITS LARVAE

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(Received for publication on 3 July 1948)

(With Plates II—IV)

THE crops such as *jowar* (*Andropogon sorghum*), maize (*Zea mays*), rice (*Oryza sativa*) and sugarcane (*Saccharum officinarum*) are often attacked by borers of *Chilo* species. The two species commonly mentioned are *Chilo simplex* Butler and *Chilo zonellus* Swinhoe. Considerable controversy exists at present regarding the identity or otherwise of these species and the ambiguity is not solved in accordance with any systematic studies. Statements by some workers show that *C. simplex* Butl. occurs on sugarcane and rice, whereas *C. zonellus* Swinh., infests *jowar* and maize. At the same time some entomologists consider these as distinct species while others think *C. simplex* a synonym of *C. zonellus*.

With a view to clarifying this long standing controversy, systematic investigations were taken up at the Agricultural College, Poona, and the morphological characters of these borers studied critically in order to bring out conclusive results.

Technique and material

For chaetotaxy, borers were collected from *jowar*, maize, and sugarcane. Permanent mounts of their head capsules and entire cuticle were prepared by treating with 10 per cent KOH solution, washing under a current of water, dehydrating, clearing in clove oil and mounting in xylol-balsam. The specimens were stained in basic fuchsin in 95 per cent alcohol. Some of the permanent slides were prepared by boiling in lactic acid instead of KOH, (in order to dissolve the fat and act directly as a fixative agent), clearing over-night in phenol crystals and mounting in Berlese's fluid. To supplement the study of setal arrangement, type of the crochets on prolegs, nature and shape of the spiracles and the position of the trapezoidal tubercles on the abdomen, were also studied. Internal anatomy was studied from fresh specimens which were fixed in water at 80°C. for two minutes and dissected under normal saline solution.

Sketches were made with camera lucida and where necessary photographs were also taken.

A few photographs of *C. simplex* and *C. zonellus* were received from the British Museum, London, and the setal diagrams of the head capsule of the caterpillar of *C. simplex* [1932] were compared and reproduced side by side with our drawings.

Historical and nomenclature

Chilo zonellus, described under genus *Crambus* by Swinhoe [1884] and by Niceville [1903], Fletcher [1928] and others under genus *Chilo*, has been placed under the family *Pyralidae* and sub-family *Crambinae*, whenever stated.

Chilo simplex Butler and *Chilo zonellus* Swinhoe are recorded from various parts of the world on different host plants but due to two schools of thought regarding their specific differentiation, the history of nomenclature is far from being simple.

The earliest record of *Chilo* borer was by Mukerji [1857] on sugarcane and Stebbing [1903] identified it as *C. simplex*. Cotes [1889, 1890, 1891, 1893, A,B.] grouped the borers from sugarcane, sorghum, and maize as *Diatraea sacharalis* Fab. Riley, in Washington, when referred to, considered them as species of *Chilo* nearing *Chilo plejadellus* Zinck. or *Chilo infuscctellus* Snel. Barlow [1900] submitted the borers of sugarcane and *jowar* to Hampson, [1898] who identified them as *Chilo simplex* Butl. Niceville [1903] observed that *Jartheza simplex* Butler [1880], *Crambus zonellus* Swinhoe [1884] and *Crambus partellus* Swinhoe [1885] were identical to *Chilo simplex* Butler. Lefroy [1906] maintained *C. auricilia* to be identical to *C. simplex*, until Dugdoen pointed out the differences to him.

Since then this borer was regarded as *Chilo simplex* Butler. However, Fletcher [1917] doubted the synonomy of the species infesting sugarcane, maize, *jowar* and rice and later on isolated these as *Chilo simplex*, *Diatraea supperessalis* (*auricilia*), *Diatraea venosata* (*striatilas*) and *Diatraea* sp. Further Flecther [1928] examined the male specimen of Butler's *simplex* from Formosa and remarked, 'I conclude that our species is not *simplex* but it seems to answer to *zonellus* Swinhoe, which may be used for the present.' At the same time be named the rice borer as *Chilo oryzae* Fletcher, since according to him the specimen of larvae from Japan which were presumably those of *Chilo simplex* Butler, did not agree with any of the Indian borers.

Kawada [1930], Kinoshita and Kawada [1932], however, consider *Chilo oryzae* Fletcher, as synonym of *C. simplex* Butler and *C. zonellus* Swinhoe a distinct species, after which the *jowar* stem borer in India is considered as *Chilo zonellus* Swinhoe.

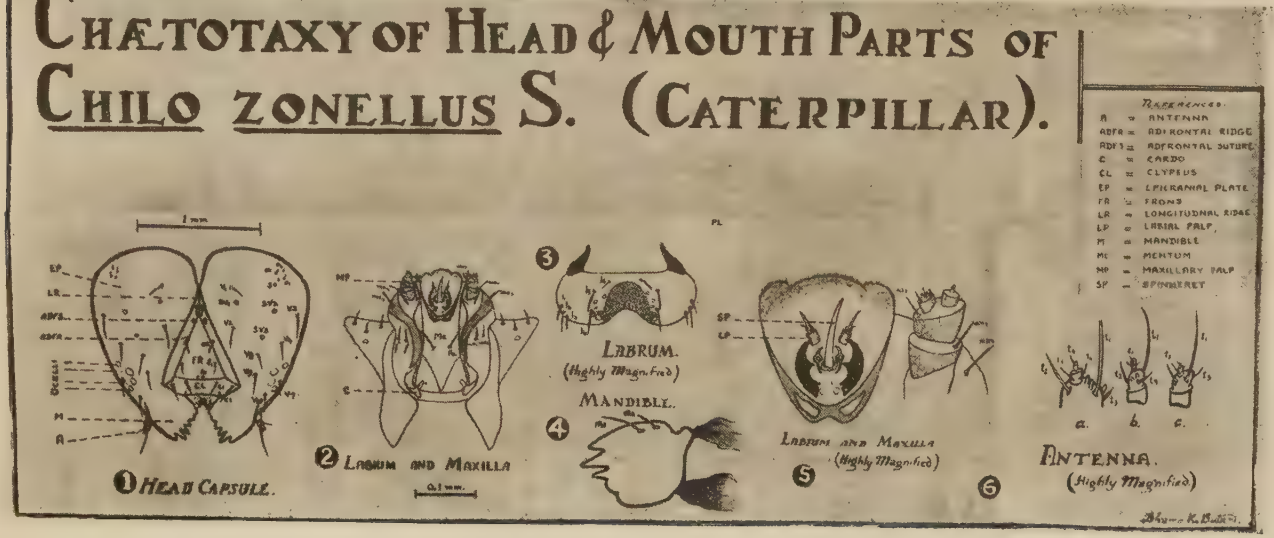
Recently, Bisset [1939] worked on these borers, and he was of the opinion that *Chilo supperesalis* Walker [1863]=*Simplex* Butler [1880] and *Chilo zonellus* Swinhoe [1884]=*partellus* Swinhoe [1885]=*Chilo trypetes* being a *sp. nov.*

Chaetotaxy

(i) *Head capsule* (Plate II, fig. 1)

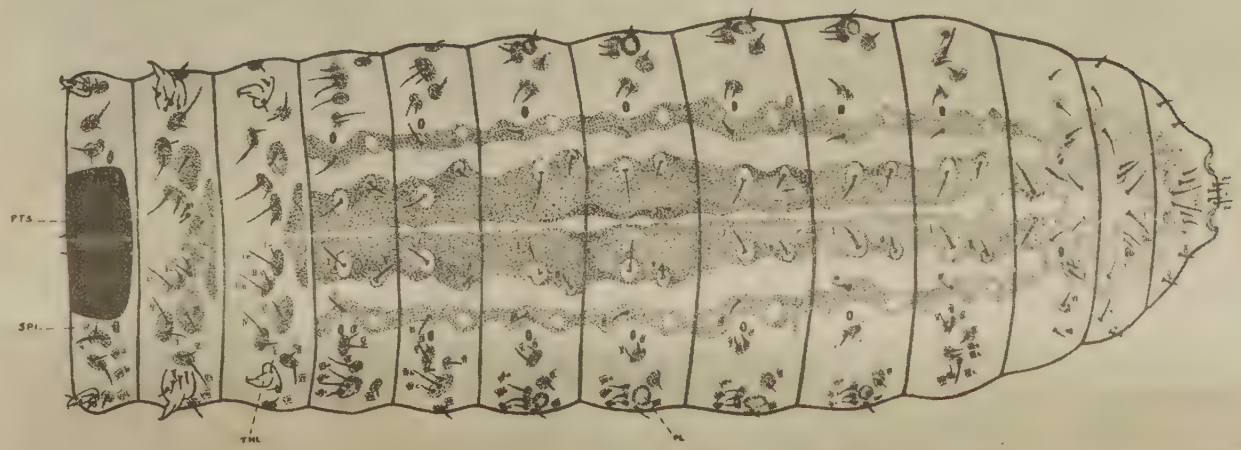
The chaetotaxy was studied according to Kinoshita and Kawada [1932] and the nomenclature adopted after them. Where necessary some arbitrary names have been introduced. Each epicranial plate bears 13 setae and four sensoria. Towards the middle of the head and near the frons, are a pair of vertical setae, v_1 and v_2, and approximately in their middle, a little away from the frons, lies a vertical sensorium, sv_1, and the second, sv_2, nearer the marginal line. Slightly below this and practically in the middle of the marginal line and the

CHÆTOTAXY OF HEAD & MOUTH PARTS OF CHILO ZONELLUS S. (CATERPILLAR).



CHÆTOTAXY OF CATERPILLAR OF CHILO ZONELLUS, SWINH.

PL = PROLEG.
PTS = PROTHORACIC SHIELD.
SPI = SPIRACLE.
THL = THORACIC LEG.



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frons lies the third vertical sensorium, sv_3. Third vertical seta, v_3, lies in line with the first two sensoria but nearer to the marginal line. Below v_3 and slightly away from the marginal line lies the fourth vertical seta, v_4 Vertical setae, v_5 v_6 v_7 and v_{10} are situated on the ocellar region, but v_5 and v_6 are not visible from the front. The seta v_7 lies within the arc made by the four ocelli, v_{10} being out of it. Setae v_8 and v_9 lie in a line below sv_3, v_9 being equidistant from v_8 and v_{10}. The rest three setae o_1, o_2 and o_3 are minute and lie on the epicranial lobe along with one sensorium, 'so'. The adfrontal sclerite bears on each side a pair of setae, a_1 and a_2, and a sensorium, 'as'. Seta a_1 lies dorsally, nearer to the angle made by the two adfrontal sutures. The adfrontal sensorium, 'as' lies near the angle made by the two adfrontal ridges, nearer to a_1 than to a_2 lies inner to the adfrontal suture and practically equidistant from 'as' and f_1. Frons are beset with one pair of frontal setae, f_1 and one pair of frontal sensoria, fs. The seta f_1 is situated nearer the adfrontal ridge and the sonsoria 'fs' close to each other. The clypeus bears two pairs of clypeal setae, c_1 and c_2, on either side ; c_1 lies near the anterior margin of the frons, and c_2 near the angle made by adfrontal sutures with anterior margin of the clypeus.

(ii) *Antennae* *(Plate II, fig. 6)

Segment I devoid of setae, II bears three setae, t_1, t_2 and t_3, the first being the longest, III bears two setae t_4 and t_5, and a small cone, which also bears one seta, t_6.

(iii) *Mouth parts*

Labrum (Plate II, fig. 3). Each bears six setae and four sensoria, of these three setae namely l_1, l_2 and l_3, lie adjacent to the anteriolateral margin, and three sensoria lie in a triangle close to each other, and the fourth one, the biggest, lies just on the marginal line near the median notch.

Mandibles * (Plate II, fig. 4). Each bears two setae, m_1 and m_2, on the anterior margin, the first being longer, lies anterior to the second.

Maxillae * (Plate II, fig. 2 and 5). Each maxilla bears five setae, mx_1 and mx_2 lie on the stipes, mx_3 on the basal segment, mx_4 on the palpiger and mx_5 on the maxillary palp. Cardo is devoid of setae.

Labium * (Plate II, fig 2 and 5). Submentum devoid of setae, with a pair lb_1. At the base of the spinneret there is a pair of sensoria s_1.

(iv) *Thorax* (Plate III)

Thoracic and abdominal setae are borne on weakly chitinized fulgidous, rounded tubercles which according to Dyar [1893-1895], Forbes [1910] and Fracker [1915] are arranged in a definite manner. Fracker [1915] has named these setae after the Greek letters, whereas Forbes in the light of Dyar's terminology gives them in Roman numbers starting from the mid-dorsal. However, Dyar studied only the chaetotaxy of abdomen.

Prothorax. The shield bears six setae arranged in three pairs ; the 1st pair, near the mid dorsal line (inner), consists of $\alpha$and β, 2nd pair γ and δ and 3rd pair τ

* Only arbitrary names are given.

and ρ. Outside the shield just below the spiracle are two setae k and η (IV and V). Inner to the base of the leg are two setae, π and υ (VIIa and VIIb) and at the outer side near the midventral line is one setσ, (VIII). All these setae are unisetiferous except III (ε and ρ) and VII (π and π) which are bisetiferous.

Mesothorax and *Metathorax*. Each of these bears six pinaculi. The first two pinaculi are bisetiferous bearing setae Ia, Ib and IIa, IIb ; third is unisetiferous bearing III, fourth and fifth are again bisetiferous bearing IV, V and VI, VII † ; and the last is unisetiferous bearing VIII. Each leg bears a whorl of setae on fe, mur and a few stray hairs on other segments.

(v) *Abdomen* (Plate III)

Segments I to VII present similar chaetotaxy. Each of these segments bears seven pinaculi. The first three pinaculi situated above the spiracle are unisetiferous and bear the setae I, II and III. Fourth pinaculus situated just below the spiracle is bisetiferous bearing setae IVa and IVb. Fifth and seventh pinaculi are also unisetiferous bearing VI and VIII, whereas sixth pinaculus is trisetose bearing VIIa, VIIb and VIIc. Pinaculi fourth to sixth are situated on the lateral side of the spiracle, inner to the leg, whereas seventh pinaculus is situated adventral or in between the two prolegs. Segment VIII bears a similar chaetotaxy except that seta VII is unisetiferous and VIII is missing. Segment IX bears six pairs of setae, III, VII and VIII missing and only the II (IIa and IIb) being bisetiferous. The anal segment bears seven pairs of unisetiferous setae namely I, II, III, V, VI, VII and VIII ; IV may be missing.

The chaetotaxy of *Chilo simplex* has not been worked out in detail so far. However, Kinoshita and Kawada [1932] have given a brief accout of chaetotaxy of the head capsule only and according to them seta a_1 in *C. zonellus* is set apart from sensorium as relatively more than in *C. simplex* (Plate IV, figs. 1 and 2).

Discussion

Since there exists a lot of controversy regarding the two species namely *Chilo simplex* Butler and *Chilo zonellus* Swinhoe their original descriptions are tabulated below in Table I.

At present there are two schools of thought, one supporting the synonymy of *C. zonellus* with *C. simplex* and the other considering them distinct species. Rahman [1946] writes, '*Chilo zonellus* Swin. and *Chilo simplex* But. are synonyms [Fletcher, 1924]. You will also be interested to know that Japanese and Chinese workers still use the name *Chilo simplex* Butl. for *Chilo zonellus* Swin.' Lal [1947] writes, 'I believe, however, that *simplex* was an old name which has been changed to *zonellus*'.

Our investigations, have shown that these are two distinct species. *Chilo simplex* Butl. probably does not occur in India, therefore, the characters of *C. simplex* (Japan), have been compared with those of the stem borer of *jowar* in India.

† Representation of IV and V and VI and VII as separate Roman numbers by Dyar indicating their bisetiferous nature is misleading, therefore we propose IVa, IVb for IV and V, and Va, Vb for VI and VII.

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EXPLANATION OF PLATE IV.

FIG. 1. *C. simplex*, a portion of head capsule
FIG. 2. *C. zonellus*, a portion of head capsule
FIG. 3. *C. zonellus*, spiracle
FIG. 4. *C. simplex*, crochets on proleg
FIG. 5. *C. zonellus*, crochets on proleg
FIG. 6. *C. zonellus*, crochets on proleg
FIG. 7. *C. simplex*, male genitalia
FIG. 8. *C. zonellus*, male genitalia
FIG. 9. *C. zonellus*, male genitalia
FIGS. 1, 2, 4 and 5 are from *J. Imp. Agric. Expt. Sta. Tokyo*, III(1), 1932
FIGS. 7 and 8 are from *British Museum*, London

TABLE I

Characters of Chilo zonellus *Swinhœ. and other allied species*

Chilo simplex Butler [1880]	*Jartheza simplex* Butler [1880]	*Crambus zonellus* Swinhoe [1884]	Remarks, according to our findings
Uncus and median process of gnathos not so long. Transtillae simple. Juxtae well developed divided in the caudal half into two lobes, the inner lobe longer than the outer lobe. Aedegus bifurcated. Yellowish brown suffused with fuscous. For-wing with the costal area rather darkest, traces of dark specks below middle of cell and at lower angle the veins of outer area slightly streaked with fuscous, a marginal series of black specks. Hind wing whitish with slight fuscous tinge. Paler, hind wings white. Expanse 22 mm.	Primaries of the male uniformly greyish-brown, minutely sprinkled with darker scales, a marginal series of black dots, fringe blackish marginal dots, and plate testaceous fringe ; secondaries slivery white, slightly greyish in male ; body corresponding in colour with the wings. Under surface white, the wings suffused with brown in the male and with testaceous in the female towards the costal margin. Expanse of wings : male 11 lines female 13 lines.	Yellowish-fawn colour, abdomen whitish, last joint of the labial palpi very long 1/10 in. abdomen extending somewhat beyond the wings. Fore-wings acute, outer border nearly straight, slightly oblique, marginal points black, darker towards the costa and outer border, a faint brown streak along the sub-costal nervure, a black dot at the end of the cell, the brown spots below, on the sub-median nurvure and a brown shadowy band running in from the apex towards the centre of hinder margin, but stopping half way, hind-wings whitish. Expanse of wings 8/10 in.	The species met with here agree more with *C. zonellus* than the other two, except that the abdomen does not extend beyond the wings. It differs from *C. simplex* by having uncus and median process of gnathos longer, juxtae simple, aedeagus not bifur-cated. Body colour is definitely yellowish-fawn and the costal area of fore-wing is always brown and not darkest. ♂ wing expanse is slightly less than that of *C. simplex*.

which we believe is definitely *C. zonellus*. The various distinct points of difference between the two species are:

1. *Larva.* (Plate IV) Spiracles of *C. simplex* are closed with no clear space in the centre, whereas those of *C. zonellus* are neither closed, nor fully open, there is definitely a longitudinal slit in the middle (fig. 3). Crochets on prolegs are in complete circle in *C. zonellus*, whereas in *C. simplex*, they are shown as horse-shoe shaped (figs. 4, 5 and 6).

2. *Pupa.* Labial palpi in *V. zonellus* invisible, front gives a large process on each side; V to VII abdominal segments provided with minute spines arranged dorsally along the anterior margin of each segment (not mentioned in *C. simplex*).

3. *Imago.* (Plate IV) C. *simplex* differs from *C. zonellus* in having proboscis well developed; uncus and median process of gnathos relatively smaller; aedeagas bifurcated (figs. 7, 8 and 9); for-that wings narrower and duller fuscous and hind-wings whiter. The general body colour of *C. simplex* is yellowish-brown and that of *C. zonellus* yellowish-fawn.

Our view regarding the identity of these species is also supported by Tams, Hinton (Br. Mus. London), Fletcher (Glouces tershire), Cherian (Madras), Bose (New Delhi) and Gupta (Central Provinces).

Since our findings have shown some contrasting characters as compared with the descriptions and photographs of *Chilo simplex*, we recommend that the species met with in India infesting *jowar* and maize may be regarded as *Chilo zonellus* Swinhoe.

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* The originals have not been referred but instead of (1) *R.A.E.* (A), XVIII, 615 and (2) Insects pests of sugarcane in India by Stebbing E.P., *Indian Mus. Notes.* V (iii) : 64-91 have been cited

BIOLOGY AND CONTROL OF *MYZUS PERSICAE* SULZER AS A PEST OF POTATO AT DELHI

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(Received for publication on 13 December 1947)

AMONG economic insects *Myzus persicae* Sulzer occupies an important position. On account of the enormously large numbers in which it makes its appearance whenever the weather happens to be conducive to its increase and due to its polyphagous habits, it is always to be dreaded as a dangerous enemy of plant life. Holdaway *et al* [1941] have pointed out that it causes serious damage to potato plants in Hawaii Islands. As a result of extensive research in Germany, Heinze [1939] found that this species was capable of transmitting twenty five virus diseases to plants including potatoes. He further concluded that an intimate knowledge of its behaviour under different environmental conditions was quite necessary to safeguard the various crops against the ravages of this pest.

Extensive work has been done on *Myzus persicae* both in America and Europe. But observations made on this species in India are rather fragmentary. The first record of this pest in this country was from Berhampur on rape by Barlow [1900]. It was then identified by Buckton as *Rhopalosiphum dianthi* Shrank. Barlow [1900] copied the description of this species from Buckton's *Monograph of British Aphididae* for its ready availability for use to Indian workers. Later in the same year he had further specimens of this insect collected from the vicinity of Calcutta attacking brinjal. Finding its distribution to be extensive in India, he gave a complete list of its European host plants. Lefroy [1909] briefly described its biology. Das [1918] studied at Lahore a part of its life-history and habits. George [1927] recorded it as a pest of tobacco at Coimbatore and Krishnamurthy [1929] on cabbage and tobacco at Bangalore. In North Bihar, some observations were recorded by Fletcher [1930] and Misra [1932]. Deshpande [1937] laid stress on its causing serious damage to cruciferous plants in Poona. In 1940, the pest was noted at Delhi by Ghulam Ullah and at Pusa by Samuel on some of its food plants and at Nilgiris by Ramakrishna Ayyar on sprouts of seed potatoes even while in godowns.

From the foregoing, the importance of this pest in India is evident. Much more knowledge about the biology, habits, and control measures of this pest is needed if its ravages are to be kept in check. This contribution embodies the results of observations continued for about two years (1944-46) at Delhi on this species as a pest of potato crop.

Technique of study

Myzus persicae was bred in large numbers on caged potted potato plants kept in a wire gauze room which provided a constant flow of aphids used in different

experiments. Aphids of the same age were selected from a single lot for the experimentation in all the replications. The method employed for the study of life-history was essentially the same as was adopted in Sumatra by De Jong [1929].

To study the damage caused by this species, seed potatoes were sown in earthen pots and kept in a wire gauze room so as to prevent any insect infestation. Six plants of about six inches height were later on selected and caged. Ten adult aphids were released on each such plant. All these plants were carefully examined daily and the course of damage, up to the death of the plants resulting from heavy infestation by the progeny of the ten adults was studied. Six plants of the same lot were similarly caged and kept as a check. These remained healthy throughout. Last of all, yields of potatoes of the infested and healthy plants were recorded.

The control of this species was tried with DDT as dust and emulsion. The dusts were prepared by thoroughly mixing 10 per cent *pp*-DDT dust with chalk powder; while emulsions of the requisite concentration were prepared by diluting with water a 25 per cent stock emulsion of the following formula:

	Parts by weight
pp-DDT	25
Benzene	33·35
Terpentine	33·35
Rectified spirit	4·90
Soap	2·80
Water	0·60
Total	100·00

DDT was dissolved in benzene-terpentine mixture. Soap was cut into small pieces, soaked with water and ground, adding rectified spirit little by little till it became homogeneous. This was then mixed with DDT solution and thus stock emulsion was formed.

Life-history

Both the apterous and alate forms of *Myzus persicae* have been observed to pass through four nymphal instars during the course of development. Though the general morphology of the earlier instars of the alatae agrees well with that of the apterae, the former differ from the latter in the final immature stage by possessing wing pads.

The life-history experiments were conducted at Delhi from September 1944 to April 1945. The biology of ten aphids was studied five times during the course of every two months, i.e., September to October, November to December, January to February and March to April. Great care was taken in selecting aphids for study and individuals of the same age and lot were used in single experiment. The average data obtained therefrom are given in Tables I and II.

TABLE I

Duration of nymphal period

Number	Month and year	Phase of aphid	Duration of nymphal instars in hours				Total nymphal period. Days-hours	Average temperature °F.	Average per cent humidity
			1st	2nd	3rd	4th			
1	September to October 1944	Apterous	19·2	21·6	27·6	36	4 , 8·4 ±2·2	85·8	62·5
2	September to October 1944	Alate	24	28·8	34·8	45·6	5 , 13·2 ±4·1	85·8	62·5
3	November to December 1944	Apterous	24	24	36	48	5 , 12 ±3·2	74·5	52·7
4	November to December 1944	Alate	24	36	43·2	48	6 , 7·2 ±3·1	74·5	52·7
5	January to February 1945	Apterous	24	36	48	60	7 , 0 ±6·3	64·7	64·5
6	January to February 1945	Alate	24	48	48	72	8 , 0 ±5·1	64·5	64·5
7	March to April 1945	Apterous	24	36	48	48	6 , 12 ±4·2	79·1	64·1
8	March to April 1945	Alate	24	36	48	60	7 , 0 ±2·1	79·1	64·1

Note: Standard deviation from the mean has been calculated and incorporated as ± hours

TABLE II

Period of maturation, reproduction total longevity and number of young ones per female

Number	Month and year	Phase of aphid	Period of maturation. Days-hours	* Period of reproduction. Days-hours	* Total longevity in days from birth to death.	* Number of young ones per female in life time	Average temperature °F.	Average per cent humidity
1	September to October 1944	Apterous	1,3·6	10,12 ±4	16·0 ±0·1	30·5 ±1·2	85·8	62·5
2	September to October 1944	Alate	3,2·4	13,21·6 ±2·1	22·6 ±0·2	20·8 ±1·5	85·8	62·5
3	November to December 1944	Apterous	1,12	12,12 ±3·2	19·5 ±0·15	30·0 ±1·8	74·5	52·7
4	November to December 1944	Alate	3,12	14,0 ±1·2	23·8 ±0·1	21·5 ±1·2	74·5	52·7
5	January to February 1945	Apterous	2,0	14,0 ±1·5	23·0 ±0·25	25·2 ±2·5	64·7	64·5
6	January to February 1945	Alate	4,0	17,7·2 ±1·6	29·3 ±0·15	15·0 ±2·1	64·7	64·5
7	March to April 1945	Apterous	1,12	13,4·8 ±1·8	21·2 ±0·1	28·9 ±1·9	79·1	64·1
8	March to April 1945	Alate	2,19·2	15,4·8 ±2·1	25·0 ±0·2	18·5 ±1·7	79·1	64·1

*Note: Standard deviation from the mean has been calculated and incorporated as corresponding ± figures.

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From Tables I and II it is evident that apterus female of *M. persicae* during September to October, when the average temperature is 85·8 Fs. and humidity 62·5 per cent, completes its development in four days 8·41 2·2 hours and in about a little more than a day later, it is fully matured to give birth to young ones. The duration of reproductive activity on an average extends to 10 days, 12 $\pm$ 4 hours, producing 30·5 $\pm$ 1·2 young ones before its death. The total life span of an individual from birth to death on an average is 10 $\pm$ 0·1 days. From Tables I and II the following indications are worth noting :

(1) During these months, on the other hand, the developmental period, the maturation period and the length of reproductive activity of the alatae are comparatively longer than those of apterae. On the whole the life span of the alataenun from birth to death is 6·6 days more.

(2) They produce about 10 young ones per female less than that of the apterae.

(3) With the decrease in temperature from November to February the various developmental periods of both apterae and alatae prolong and the number of off springs per female diminishes.

(4) During March and April when the temperature again rises, there is a corresponding shortening of developmental periods with a rise in number of young ones of both the alatae and the apterae.

(5) A careful study of the data further indicates that the life from birth to death of the alatae is considerably longer than that of the apterae, but the number of progeny in the former during the course of its life is much less than that of the latter.

(6) As humidity has been varying with temperature we cannot detect separate effects of humidity but the variation from 52·7 per cent to 64·5 per cent is not likely to have a significant effect.

It may be pointed out that during the course of study, it was also observed that the progeny of the adult alatae is predominently apterous, whereas the apterae produce variable proportions of apterous and alate offsprings.

It may be mentioned here that in Sumatra, De Jong [1929] observed *M. persicae* to mature in seven days after birth and 50 young ones were produced by a single female, whereas the present experiments recorded the maturation of some aphids (i.e. alatae) after three to five days the average being four days during January to February and the number of offsprings to be 21 to 40, the average being 30·5 per apterous female during September to October. This disparity may be attributed on the one hand to the different environmental conditions prevailing at Delhi and Sumatra and on the other hand to the different local strains of the same species occurring at these two distant places.

The greater longevity of alatae than that of apterae seems to give the former more time for dispersal and transmission of plant virus diseases if they are carrying any infection. Moreover, since the alatae having once settled down on a particular host, produce mostly apterae, the latter's more rapid production of the progeny

leads to an enormous population within a short time which is obviously detrimental to any vegetation.

Food plants

M. persicae is polyphagous attacking almost all sorts of green vegetation. A comprehensive list of its food plants as recorded from different parts of the world, has been given by Patch [1938]. According to him it has been recorded on 321 species belonging to 67 natural orders of plants. At Delhi, Ghulam Ullah [1940] observed host plants of this aphid comprising of potato (*Solanum tuberosum*), tobacco (*Nicotiana tabacum*), turnip (*Brassica rapa*), *rai* (*B. juncea*), *sarson* and *toria* (*B. campestris*), cabbage and cauliflower (*B. oleracea*), radish (*Rhaphanus sativa*), hollyhock (*Althea rosea*), safflower (*Carthamus tinctorius*), beetroot and spinach (*Beta vulgaris*) and wild plants such as *Orobanche* spp., *Malva sylvestris*, *Marcona grandiflora*, *Convolvulus* spp., *Phlox* spp., and *Solanum indicum*. The author has also recorded this species on the above mentioned plants expecting safflower, beetroot, spinach and the wild ones; his list of hosts further includes brinjal (*Solanum nmelongena*), black nightshade (*S. nigrum*), tomato (*Lycopersicon esculentum*), *datura* (*Datura metel*), cotton (*Gossypium* spp.), *bhindi* (*Hibiscus esculentus*), *Dalbergia sisso*, pea (*Pisum sativum*), *Phaseolus vulgaris*, *Chrysanthamum* spp., peach (*Prunus persica*), wheat (*Triticum vulgare*), *Chenopodium* spp., castor (*Ricinus communis*), carrot (*Daucus carota*), *til* (*Sesamum* spp.) and *Cucurbita* spp.

Seasonal history

Myzus persicae is abundant during September to December mainly on plants of Solonaceae, *Brassica* spp. etc., producing a number of asexual generations. During November and December, autumn migrants appear occasionally and disperse, some going to peach trees. The colonies, whence the autumn migrants originate, reproduce asexually but there is hardly any perceptible diminution in the numbers of individual aphids within the colonies due to migration. During winter, however, the population definitely decreases but the cold climate is not detrimental to aphid life so that viviparous females remain active after sunrise even on the coldest days. With the advent of spring, breeding proceeds rapidly and in March to April colonies are again teeming with individuals. About the beginning of May, however, the colonies practically disappear probably, partly due to excessive heat and partly due to shortage of food, as all vegetation has a diminished flow of sap resulting from the extreme hot and dry weather. Nevertheless they once again appear on their host plants, rather suddenly after rains, i.e., at the end of August and the beginning of September. It is not known how this aphid tides over the summer, during its apparent absence from the host plants.

Lefroy [1909] pointed out that in India, sexual forms for laying 'over-wintering egg' have not been shown to occur. The fact that the viviparous females remained active even on the coldest days suggested to him that the production of oviparous females was not necessary to tide over winter under the Indian climatic conditions. This statement is, however, contradicted by Das [1918] who, while working at

Lahore maintained that in addition to continuous parthenogenetic reproduction throughout winter, the autumn migrants, which continue flying to peaches during December, include both males as well as females, and the alate females produce pathenogenetically apterous oviparous females, which after fertilization lay over-wintering eggs in January and these hatch out in the ensuing spring. At Delhi, the author is unable to trace any sexual individuals and this may, probably, be due to slightly milder winter in Delhi than at Lahore. As regards its absence in summer, Das [1918] advances the view that during this period it either migrates to cold moist places or lays eggs before the onset of summer. Neither adults nor eggs are noted anywhere at Delhi in summer and this aspect of the problem still remains unsolved.

Damage caused to potato plants

M. persicae attacks the leaves in the beginning generally from the lower surface. When its population increases it spreads practically to all parts of the foliage. In New York, Gyrisko *et al* [1946] observe that it inhabits the lower levels of potato plants, but the author notices that it does not seem to show much reference to any special part of the plant. but often its attack is more concentrated on tender leaves of growing shoots which actually form upper level of potato plant. The first sign of injury on foliage resulting from the continuous desapping by this insect appears within two or three days depending on its population. The terminal growth is retarded and the new leaves do not grow to normal size. The course of injury, though gradual, causes discoloration followed by yellowing of the leaves which droop down as if lifeless and ultimately dry up. The lower older leaves prematurely drop off and this phenomenon is also observed by Nottingham and Rawlins [1941] at Long Islands.

As mentioned in the beginning, ten adult aphids were released on each of the six potted potato plants and allowed to multiply. The aphid population gradually increased to enormous numbers and ultimately resulted in the death of the plants. The yield of potatoes of these infested plants and that of six other healthy uninfested plants were recorded. It was found that average yield per infested plant was 0·58 lb. whereas that of uninfested control plant was 1·24 lb. The decrease in the yield of tubers resulting from the attack of the aphid, as recorded by the author, was also noted by Nottingham and Rawlins [1941] at Long Islands.

Effect of DDT on *Myzus persicae*

The literature on the efficacy of DDT in controlling aphids is very meagre and whatever information is available is conflicting and far from encouraging. In England, Shaw [1945] reviewed the literature on the effect of DDT on aphids and put forth the view that it might be due to the parthenogenetic reproduction of aphids even after the action of DDT and some of the young ones thus produced might escape death to establish new colonies. This view was later on confirmed in the U.S.A. by Smith [1946].

DDT has been found to be quite effective against *Macrosiphum solanifolii* Ashm. in Iowa Bruce and Tauber [1945], Nebraska, Hill [1945] and in Long Islands [Gyrisko *et al.* 1945]. Both Hill and Gyrisko *et al.* have included *Myzus persicae* Sulz. also to this exceptional category. Gyrisko *et al* have, however, reported that the control of both these potato aphids has been better with DDT than rotenone or nicotine. In New York, Gyrisko and collaborator [1946] have contributed some more useful information on these lines. A method of field application by gas aerosol dispersion has been found by Smith and coworkers [1945] in the U.S.A. to be very promising as a means of aphid control in heavily infested potato plantings. The following observations add to the existing knowledge of the effect of DDT on *Myzus persicae* and are therefore worth recording.

Hundred gravid individuals of *M. persicae* (both apterous and alate in equal proportions) were released on small potato plants kept in glass cages. Then some were dusted with dusts of DDT of different concentrations by means of a small hand-dusting machine (waldust) till a fine white deposit of the material was visible on the foliage ; and the others were sprayed with emulsions of various concentrations of DDT by means of small hand-sprayer till the leaves got a good wash with the spraying material. Thus, 2 oz. of either dust or emulsion were used for the treatment of each plant. Each experiment was repeated five times. The same number of aphids for each set of experiments were kept on a plant under the similar conditions without DDT treatment and these served as a control. At the base of treated plants white sheets of paper covering the area around them under the cages were kept. The margins of these papers were ringed with tangle-foot to prevent the escape of aphids. When examined two , four and six days after treatment, the affected aphids were either dead or in the various stages preceding death. Among the affected aphids were frequently seen normal appearing young ones in the first instar. It was also observed that the effected individuals, with bodies somewhat contracted for lack of food, were producing offsprings for as long as two days and sometimes even up to three or four days. The observations are given in Tables III and IV.

It is evident from the experimental data that *Myzus persicae* can be successfuly controlled with a low concentration of DDT such as 0·5 per cent spray emulsion when a cent per cent mortality is achieved within two days. A much higher strength of DDT dust (i.e. 10 per cent) is required to produce the same effect. In view of this, it is much better to use DDT spray emulsion rather than dusts when this aphid is to be dealt with. A five per cent dust and a spray emulsion of 0·125 per cent to 0·25 per cent gives more than 90 per cent kill of the aphid after two days, but cent per cent kill after four days and at the same time the young ones are not produced by the affected aphids. As no separate popultion counts for individuals of *Myzus persicae* and *Macrosiphum solanifolii* have been taken by Gyrisko *et al.* [1945] in Long Islands it is not possible to have a complete idea from their observations about the effect of DDT on *M. persicae.* In New York Gyrisko *et al* [1946] have reported that 0·125 per cent DDT spray powder kills more than 90 per cent *M. persicae* even after 16 to 18 days. They have also suggested the use of maximum

dose, e.g., 2 lb. per 100 gallons (i.e. 0·25 per cent DDT) when an adequate control of aphids is to be effected. The author's observations no doubt indicate a very high percentage mortality of *M. persicae* (i.e. 99·2 per cent) with 0·25 per cent DDT emulsion.

TABLE III

Effect of DDT on aphids

Number	Treatment	Average per cent mortality after two days	Average per cent mortality after four days	Average per cent mortality after six days
	DDT dust per cent			
1	10	100	100	100
2	5	99	100	100
3	2·5	88	100	100
4	1·0	78·4	85	100
5	0·5	75·2	84·2	100
6	0·25	65·2	80·4	100
7	0·125	55	70·8	96
8	0·05	36·2	60·6	90
	DDT emulsion—(per cent)			
9	1·0	100	100	100
10	0·5	100	100	100
11	0·25	99·2	100	100
12	0·125	96·2	100	100
13	0·05	80·6	90·2	100
14	0·025	50·4	70·8	93·4

TABLE IV

Young ones produced by affected aphids

Number	Treatment	Percentage of aphids affected by treatment from all five replications (these were producing young ones)	Number of young ones per affected aphid
	DDT dust per cent		
1	10	0	0
2	5	1	0
3	2·5	12	0·166
4	1·0	21·6	0·259
5	0·5	24·8	0·338
6	0·25	34·8	0·488
7	0·125	45	0·515
8	0·05	63·8	0·601
	DDT emulsion—per cent		
9	1·0	0	0
10	0·5	0	0
11	0·25	0·8	0
12	0·125	3·8	0
13	0·05	19·4	0·195
14	0·025	49·6	0·395

Most of the DDT treatments, other than five per cent dust and 0·125 per cent to 0·25 per cent emulsion give in some cases a high percentage of aphid mortality, yet these are of less use from the control point of view due to the production of young ones by the affected adults which found new colonies when transferred to untreated plants. In Beltsville, the United States of America, Weigel [1944] has mentioned that a 0·025 per cent DDT spray (i.e., 4 lb. of five per cent DDT per 100 gallons) on snapdragon cuttings has given a kill of 38 per cent *M. persicae* within two days, whereas the author has found that a 0·025 per cent DDT spray emulsion destroys on an average 50·4 per cent aphids. A three per cent dust used by Weigel [1944]

indicates a destruction of 51 per cent *M. persica* after four days, but on the other hand a 2·5 per cent dust employed by the author kills cent per cent aphids after four days. The difference in these observations from those of Weigel [1944] may be due to either the difference in the type of sprays and dusts used, as he has not mentioned the way how his dusts and sprays were prepared or due to the difference in the quality of DDT in both the cases or lastly may be due to the difference in the resistance of aphids occuring at Beltsville, the United States of America and Delhi.

The parthenogenetic reproduction by the affected adults which are capable of starting new colonies, surely, is in agreement with the views put forward in England by Shaw [1945] on aphids in general and Smith [1946] in the U.S.A. on *M. persicae* and *Macrosiphum solanifolii* Ashm. The latter said that DDT neither affects the offsprings within the mother nor prevents their birth. It may be stated on the basis of the experiments conducted by the author that this seems to be true only in the case of sub-lethal doses of DDT which Smith [1946] also probably means but when five to 10 per cent dust or 0·125 per cent to 1·0 per cent spray emulsion of DDT are used the adult aphids die without producing the offspring.

The DDT as dust or emulsion was applied at the rate of 2 oz. per potato plant in different concentrations. Alate and apterous aphids in equal proportions were then released in batches on the treated plants. The aphids of the second or third batch were only released on the plants when all the individuals of the preceding batch had died. The experiments were repeated five times. The plants were examined daily and records of the cent per cent mortality were taken. These are presented in Table V.

TABLE V

Residual effect of DDT on the mortality of Myzus persicae *on potato plants*

Number	Treatment	First release number of aphids	100 per cent mortality after days	Second release on 11th day. Number of aphids	100 per cent mortality after days	Third release on 24th day. Number of aphids	100 per cent mortality after days
	DDT dust Per cent						
1	10	50	1	10	1	10	3 to 4
2	5	50	2 to 4	10	2 to 4	10	4 to 6
3	2·5	50	3 to 4	10	3 to 5	10	6 to 7
4	1·0	50	5 to 6	10	5 to 8	10	7 to 9
5	0·5	50	5 to 6	10	6 ro 9	10	90 per cent mortality after ten days

TABLE V—*contd.*

Residual effect of DDT on the mortality of Myzus persicae *on potato plants*

Number	Treatment	First release number of aphids	100 per cent mortality after days	Second release on 11th day. Number of aphids	100 per cent mortality after days	Third release on 24th day. Number of aphids	100 per cent mortality after days
	DDT dust Per cent						
6	0·25	50	5 to 6	10	8 to 10	10	90 per cent mortality after ten days
7	0·125	50	7 to 8	10	8 to 11	10	80 per cent mortality after ten days
8	0·05	50	8 to 10	10	10 to 12	10	60 per cent mortality after ten days
	DDT Emulsion Per cent						
9	1·0	50	1	10	1	10	2 to 4
10	0·5	50	1 to 2	10	2 to 3	10	4 to 5
11	0·25	50	2 to 4	10	3 to 5	10	5 to 7
12	0·125	50	3 to 4	10	4 to 6	10	80 per cent mortality per cent after ten days
13	0·05	50	5 to 6	10	5 to 8	10	80 per cent mortality after ten days
14	0·025	50	8 to 9	10	7 to 9	10	50 per cent mortality after ten days

It is evident from the data that the higher the concentration of either dust or spray of DDT the sooner the cent per cent mortality of the aphids is achieved and the residual effect lasts longer. The dusts of 1·0 per cent to 10 per cent and the emulsions of 0·25 per cent to 1·0 per cent are quite effective in destroying cent per cent aphids even after four or five weeks.

DDT poisoning produced practically the same symptoms on *M. persicae* as were noted by various entomologists on other insects. Sometime after the dusting

or spraying, depending on the concentration of the DDT used, the aphids stop feeding and a tremor commences in their entire body which is followed by un-co-ordinated movements of the limbs. The cessation of feeding results in the shrivelling of their body till ultimately death supervenes. When ten per cent DDT dust and 0·5 to 1·0 per cent emulsion are used these symptoms appear in a somewhat rapid succession.

Lastly it might be pointed out that all the concentrations of DDT dusts and emulsions used in these experiments lacked any phytocidal action on the potato plants as they did not show any sign of damage due to DDT poisoning and remained absolutely healthy.

Summary

The life-history of *Myzus persicae* Sulzer under the climatic conditions of Delhi has been studied during different seasons. September and October appear to be most favourable months to it and the average total longevity from birth to death of the alate and apterous forms has been 22·6 ± 0·2 days and 16·0 ± 0·1 days, nymphal period 5 days, 13·2 ± 4·1 hours, and 4 days, 8·4 ± 2·2 hours, maturation period 3 days, 2·4 hours and 1 day, 3·6 hours, period of reproduction 13 days, 21·6 2·1 hours and 10 days, 12·4 hours, and the average number of young ones per female produced in its life time 20·8 1·5 and 30·5 ± 1·2 respectively. The significance of the short life span and increased reproductive capacity of the apterae as compared to those of alatae has been discussed.

The seasonal incidence of this species at Delhi has been described. The period of its greatest activity has been found to be from September to December and it is considerably active during March and April as well. No oviparous females have been observed at Delhi.

This species is polyphagous and has been recorded at Delhi on 27 species of host plants belonging to 12 natural orders. The reduction in the yield of potato tubers due to aphid infestation on potted plants has been estimated to be 0·58 lb. per plant against 1·24 lb. of a healthy one.

The effect of DDT on this aphid has been studied applying either dust or emulsion at the rate of 2 oz. per plant. A 0·5 per cent spray emulsion is quite effective against this pest and gives cent per cent kill within two days. A ten per cent dust has also given the same results, but in this case the quantity of DDT used is much more than the amount of DDT in 0·5 per cent emulsion.

Emulsions of 0·125 per cent to 0·25 per cent and dusts of 2·5 per cent to 5 per cent destroy cent per cent aphids within four days. Emulsions of 0·025 per cent to 0·05 per cent and dusts of 0·05 per cent to 1·0 per cent give various degrees of mortality after two, four and six days, but some of the affected aphids from these treatments produce healthy offsprings which are capable of establishing colonies when transferred to untreated plants.

Symptoms produced in aphids as a result of the action of DDT are the same as described in other insects. Emulsions of 0·025 to 1·0 per cent and dusts of 0·05 per cent to 10 per cent DDT do not show phytocidal action on potato plants.

Acknowledgments

I am much indebted to Dr Hem Singh Pruthi, Sc. D. for suggesting this problem and deputing me on this work in 1944. This was supplemented by the guidance of Dr Taskhir Ahmad for which I tender my sincere thanks and owe a debt of gratitude to him. I am grateful to Dr S. Pradhan for going through the manuscript, offering relevant criticism and valuable suggestions. I also acknowledge the ungrudging assistance given to me by Mr. F. L. Chowdhary, Junior Scientific Assistant, in this piece of work.

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CANNING OF GRAPES IN BALUCHISTAN

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(Received for publication on 29 November 1946)

THE fruit canning industry has advanced rapidly during the past few years in the United States of America, England and Australia. Firuts like apricots, peaches, pears, plums, berries, etc., are canned to a large extent in these countries. Standard methods for canning these and several other fruits have been given by Cruess [1938]. Much research work has been done at the Fruit Products Laboratory, University of Claifornia, the National Canners' Association, Washington and some other research centres in America. In England, the Fruit and Vegetable Preservation Research Station, Campden (Glos) has been doing important work on the canning of typically English fruits and berries. In India, there has been recently much interest in the subject as a result of the impetus given by the †Imperial Council of Agricultural Research financing research scheme at Lyallpur, Quetta, etc. A short account of the results obtained at Quetta during 1938 to 1943 has been published in the form of a bulletin [Siddappa and Mustafa, 1946].

Quetta is an important fruit growing centre. Apart from peaches, plums, apricots and other fruits, grapes of high quality are also grown. Further large quantities of grapes from Afghanisthan are imported through Chaman and Quetta. The seedless *kishmish* and the large seeded *haitha* are the two most important varieties of grapes grown. A large number of other varieties, local as well as imported, are also available to some extent. An account of the ripening changes in some of these varieties has been published [Siddappa, 1942, 1]. Grapes are not canned much in any part of the world. It was, therefore, decided to carry out systematic investigations on the possibility of canning some of the famous Quetta grapes. A preliminary account of these investigations has been given in a series of annual reports of the Fruit Canning and Preserving Research Scheme, Quetta, from 1938 to 1943. As the results are of considerable interest, they are now presented in this paper. The Research Scheme has since been continued jointly by the †Imperial Council of Agricultural Research and the Baluchistan Administration, as the preliminary work has given very encouraging results.

Material

Although a large number of varieties of grapes, white as well as coloured, were available, only the most important of these, namely, the seedless *kishmish* and the seeded *haitha*, were used in the main investigation. The *kishmish* is a small seedless

* Now in Madras Agricultural Service.
† Now Indian Council of Agricultural Research.

white grape which turns straw yellow when fully ripe. It corresponds to the Thompson's Seedless of California. The berries are round to slightly oblong with a mellow golden colour and a pleasant acid sweet pulp. When fully ripe, the juice has a Brix value of 25-28 degrees and an acidity of 0·4 to 0·6 per cent, as tartaric acid. The *haitha* is generally a large seeded grape, slightly oval in shape, and when fully ripe, it has thick skin and greenish yellow melting pulp. The juice is of 17 to 23 degrees. Brix and 0·3 to 0·5 per cent acidity, depending upon locality [Siddappa, 1942, 1]. It is thus a sweet grape low in acidity, and, as such, is valued as a high class table grape.

Unless otherwise stated, the grapes used in these experiments were got from vineyards and the local market which is one of the most important distributing centres for the *Kandhar* grapes. A few samples were got from the grape variety collection plots at the Fruit Experiment Station, Quetta. Fully ripe grapes were used for canning, while the under-ripe or over-ripe berries were set aside for drying or juice making.

Method

The canning machinery and equipment installed at the Fruit Products Laboratory Quetta, have been fully described elsewhere [Siddappa, 1942, 2]. Those were employed for the present work also. Unless otherwise stated, the following procedure was standardized for canning the grapes.

The bunches of grapes were washed in cold running water and allowed to drain on large flat-bottom wooden trays. The berries were removed from the bunches by hand and the cull fruit and stems were sorted out. The cleaned berries were filled into A $2\frac{1}{4}$ size cans, plain or lacquered, and covered with syrup of 40 degrees Brix at 170°F. to 175°F. leaving $\frac{1}{4}$ inch headspace by suitably adjusting the guide rails on the syruper chain below the syrup-filling pipe line. The filled cans were passed through the exhaust box and a seven minutes exhaust in steam was given and then immediately double seamed. The cans were then processed for 25 minutes in boiling water in an open tank. (Water boils at 202°F. at Quetta which is 5540 feet above sea level). After processing, they were quickly cooled in cold water to about 110°F. drained, wiped dry and stored at ordinary room temperature for further observation. The cans were examined after different periods of storage of four to five months by the standard cut-out technique.

Results

Data regarding a few typical experiments on the canning of grapes are given in Table I. Both *haitha* and *kishmish* grapes give very good canned products. Plain cans are quite suitable for canning them. In the case of the *haitha* grape, there is a tendency for the berries to split in the can. The *kishmish* grape, on the other hand, does not split. It develops an attractive golden yellow colour in the can. Being seedless, it is preferred to the seeded *haitha* grape. There appears to be a considerable demand for canned *kishmish* grapes as such and also for use in the preparation of mixed fruit salads. The removal of the caps from *kishmish* grapes is

TABLE I

Canning of grapes (1939-1941)

Experiment number	Date	Particulars	Weight of bunches of grapes taken in lb.	Syrup strength degrees Brix	Exhaust minutes	Process minutes	Number of cans packed A 2½ (Plain)	Weight of fruit required per can lb.—oz.	Remarks
G. 4	18 September 40	*Kishmish* grapes of good quality; ripe; rather small berries [100 berries-90 gm.]	20	45	8	25	16	1-4	Plain can used. Berries capped by hand, which is laborious and time consuming. Cut out after 4 months:—Berries yellow and unbroken. Syrup clear and bright. Taste and flavour very good, Inside of can remarkably free from any stain
G. 5	26 September 40	*Kishmish* grapes; yellowish berries of good quality. Purchased from market. There was much wastage during grading.	82	40	8	25	47	1-12	Three workers required to steam and cap the berries. Canned product in excellent condition after 3 months
G. 7	28 August 41	*Kishmish* grapes from a local vineyard; ripe and of good quality.	174	40	7	25	111	1-9	Good canned product. Fruit and syrup in excellent condition. Can not affected even after 4 months' storage
G. 1	26 October 39	*Haitha* grapes. Firm ripe purchased in market 80-85 berries per A 2½ can corresponding to 1 lb.—6 oz. of grapes.	8	45	6	25	4	2-0	Cut out after 4 and 5 months. storage: Grapes slightly split up and pale yellow in colour. Syrup clear and bright. Taste rather sweet. Flavour good. Inside of can in sound condition. A good canned product
G. 3	18 September 40	*Haitha* grapes. Purchased in market. Over ripe and small berries predominating. Much wastage during preparation.	82	45	8	25	46	1-13	Cut out after one week: Berries split. Syrup clear. Can not stained. A good canned product. Cut out similar even after 4 months' storage

at present a laborious and slow process, but mechanical stemming and capping as in the case of red and black currants will quicken the process considerably. There is much scope for developing the grape-canning industry in Baluchistan.

When fruit lacquered cans were used instead of plain ones for canning *kishmish* grapes, the lacquer was not affected and it remained unbroken. In one lot of canned *kishmish* grapes packed in 40 degrees Brix during 1941, a few berries had split, but the syrup was clear. At the bottom of the can, however, there were a few glistening crystals, possibly of potassium hydrogen tartrate. These were not examined chemically. It is however well known that grape juice, when stored in the cold, has a tendency to deposit ' argol ' i.e , potassium hydrogen tartrate.

Semi-commercial trials and cost of production

Encouraged by the fact that canned grapes were well received by the public, a small scale commercial pack was turned out during 1942, when 970 cans were produced. A larger pack could not be undertaken, as during the grape season the canning plant was utilised for the large scale canning of tomatoes. Plain A 2½ cans, 40 degree Brix syrup, a steam exhaust of seven minutes and a process of 30 minutes in boiling water were adopted as the standard method. From each maund of grapes only about 45 cans were packed on account of the poor quality of the grapes available. The yield will be much higher, 55 to 60 A 2½ cans, in the case of good graded grapes.

During 1945, 6750 cans of grapes were packed along with large quantities of other products like canned apricots, plums, tomatoes, etc., to the extent of 61067 cans in all. The cost of production of an A 2½ can of grapes is given in Table II. Complete details regarding the working out of the cost of production of canned fruit under Baluchistan conditions have already been published [Siddappa, 1942,2]. The cost of production of an A 2½ can of grapes came to annas fifteen and pies seven exclusive of any allowance for probable spoilage during storage. It will be desirable to add two to three per cent of the total cost to meet this contingency. The cost due to coal, labour, electricity and label has been deduced proportionately on the assumption that it is approximately the same for each unit of the different types of product packed. The cost of grapes at Rs. 30 per maund was nearly twice the normal price. Due to war time conditions, the cost of coal and labour were also high. In normal times it may be possible to pack an A 2½ can of grapes at about twelve annas, which is quite reasonable. Baluchistan having the monopoly for high class grapes, the grape-canning industry there has a bright future.

Summary

The results of an investigation into the possibility of canning grapes in Baluchistan are reported in this paper. Of the two important varieties of grapes, the seedless *kishmish* grape gives an excellent canned product, when canned in 40 degree Brix syrup in plain cans. The large seeded *haitha* grape also gives a good canned product but the berries have a tendency to split in the can. Canned grapes can be used as such or as fruit salad with other fruits.

TABLE II

Cost of production of an A 2½ can of grapes (1945).

Item number	Details	Total quantity	Amount	Cost per can, pies	Per cent of total cost	Remarks
			Rs. as. ps.			
1	A 2½ flatted can	6750*	1,174 3 0	33·22	17·76	At Rs. 173 per 1,000 cans, i.e., 33·22 pies per can (flattened)
2	Grapes	111 md. 37½ sr.	3,358 2 0	95·52	51·06	At Rs. 30 per maund
3	Sugar	42 md. 13 sr.	850 12 0	24·20	12·93	At Rs. 20-1-7 per maund
4	Coal	do.	228 15 0	6·51	3·48	990 maunds during the season at Rs. 2-1-6 per maund delivered at the factory
5	Labour	..	622 3 0	17·70	9·46	Rs. 5628-13-0 was spent during the season. High due to discontinuous working
6	Electricity	..	96 0 0	2·73	1·46	Rs. 927-10-0 was spent on miscellaneous charges like electricity, cloth, washing, etc
	Labels	..	66 13 0	1·90	1·02	Rs. 8-60 per 1,000. Total expenditure was Rs. 604-11-0
8	Supervision	..	81 0 0	2·30	1·23	Approximate. Deduced on the assumption that Rs. 1,800 will be required for a total production of 150,000 cans in about 6 months' times
9	Depreciation	..	105 7 0	3·00	1·60	Approximate. Three pies per can on the basis of a total investment of Rs.40,000 on buildings, and machinery and a production of 150,000 cans in the season
	Total		6,583 0 0	187·08	100·00	

When good graded grapes are used, as in 1945, the yield will be as high as 60 cans of A $2\frac{1}{2}$ size per maund of grapes. With ordinary commercial lots, however, it is safe to assume an yield of 50 to 55 cans only. When the grapes are of poor quality, the yield may be about 45 cans only.

The cost of production of an A $2\frac{1}{2}$ can of *kishmish* grape came to only fifteen annas and pies seven in 1945 even under wartime conditions when the price of fruit, labour, etc., was very high. Baluchistan having the monopoly for high quality grapes, the grape-canning industry there has a bright future.

Acknowledgements

The authors' thanks are due to the Imperial Council of Agricultural Research and the Baluchistan Administration for jointly financing the Research Scheme under which the work was done and to Mr. A. M. Mustafa, M. B. E., the then Director of Agriculture Baluchistan, for his keen interest in the investigation.

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* LIST OF COMMON NAMES OF INDIAN PLANT DISEASES

Abies pindrow Spach	
Fomes annosus Fr.	Annosus Butt Rot
,, *fomentarius* (L.) Fr. var. *inzengae* Fr.	Heart Rot
,, *igniarius* (L.) Fr.	Heart Rot
,, *pinicola* Fr.	Red Belt Fungus, Brown Crumbly Rot
,, *roseus* Fr.	Brown Cubical Rot
Lenzites betulina (L.) Fr.	White Spongy Sap Rot
,, *repanda* (Mont.) Fr. . . .	White Sap and Bark Rot
,, *sepiaria* Fr.	(Dry Rot) Brown Cubical Rot
,, *subferruginea* Berk (*Glycophyllum edule* Murr.)	Brown Cubical Rot
Merulius tremellosus Fr.	Slash Rot
Peridermium sp.	Needle Rust
Polyporus adustus (Willd.) Fr. . . .	White Spongy Sap Rot
,, *calcuttensis* Bose . . .	Brown Sap Rot
,, *cuticularis* (Bull.) Fr. . .	White Spongy Rot
,, *schweinitzii* Fr. . . .	Butt Rot
,, *sulphureus* Fr. . . .	Butt Rot
Polystictus abietinis Fr.	White Pitted Sap and Heart Rot
,, *elongatus* Berk. . . .	White Pocket Rot
Poria Sp.	White Spongy Rot
Trametes pini (Brot.) Fr. . . .	Red Ring Rot
Abies smithiana Forbes.	
Peridermium thomsoni Berk. apud. Cke. .	Needle Rust
Acacia arabica Willd. Babul	
Fomes badius Berk	Spongy Heart Rot or Butt Rot
Ganoderma lucidum (Leyss.) Karst. . .	White Spongy Sap and Heart Rot
Septogloeum acaciae Syd. . . .	Leaf Spot
Acacia auriculaeformis. A. Cum.	
Ganoderma lucidum (Leyss) Karst.	White Spongy Sap and Heart Rot
Stereum nitidulum Berk.	White Spongy to Fibrous Rot

* The List of Common Names of Indian Plant Diseases was compiled by a sub-commitee appointed by the Plant Pathology Committee of the Indian Council of Agricultural Research. The List contains the names of diseases found in India on hosts of economic importance. The hosts include not only cultivated crops and fruit trees but also forest trees of India ; the total number of hosts listed is 279.

The list is arranged in alphabetical order, recording to the scientific names of the host plants. The common names (English and Indian) of the host plants are given where possible.

The *List of Common Names of British Plant Diseases* published in 1934 has been freely consulted and where possible the common names listed in that publication have been adopted.

Acacia catechu Willd. *Cutch, Katha*	
Erysiphe acaciae Blumer	Mildew
Fomes badius Berk. (*F. pappianus* Bres.)	Spongy Heart Rot or Butt Rot
,, *fastuosus* Lev.	White Pocket Heart Rot
,, *lividus* Kalchor	White Spongy Rot
,, *rimosus* Berk.	Spongy Yellow Heart Rot
Microstroma acaciae Syd.	Leaf Spot
Ravenelia tandonii Syd.	Rust
Acacia cyanophylla, Lindle	
Polystictus versicolor (L.) Fr.	White Spongy Sap Rot
Acacia leucophloca Willd.	
Ganoderma lucidum (Leyss) Karst.	White Spongy Sap and Heart Rot
Acacia modesta, Wall.	
Fomes rimosus Berk	Spongy Yellow Heart Rot
Acacia sundra, Budd.	
Fomes badius Berk	Spongy Heart Rot or Butt Rot
Acer caesium Wall.	
Daedalea flavida Lev.	White Spongy Rot
Polyporus secernibilis Berk.	White Spongy Rot
Rhytisma acerinum (Pers.) Fr.	Tar Spot
Acer oblongum Wall.	
Schizothyrium annuliforme Syd. and Butler	Tar Spot
Trametes lactinea Berk.	White Sap Rot
Acer pictum Thunb.	
Rhytisma acerinum (Pers.) Fr.	Tar Spot
Acer villosum Wall.	
Lentinus subnudus Berk.	White Spongy Sap and Heart Rot
Achras zapota L. (***Sapota achras*** Willd.) *Sapota Chikku*	
Capnodium sp.	Sooty Mould
Acrocarpus fraxinifolius Wight	
Ganoderma lucidum (Leyss) Karst.	White Spongy Sap and Heart Rot.
Trametes lactinea Berk.	White Sap Rot
Adhatoda vasica Nees Malabar nut, *Basak*	
chnoospora butleri Diet. and Syd.	Greasy Rust
Aesculus indica Colebr.	
Armillaria mellea (Vah.) Quel.	Armillaria Root Rot
Asterostromella rhodospora Wakef.	White Soft Fibrous Rot
Fomes senex Nees and Mont.	White Sap and Heart Rot
Lenzites betulina (L.) Fr.	White Spongy Sap Rot
Merulius tremellosus Schrad.	White Spongy Slash Rot
Polyporus adustus (Willd.) Fr.	White Spongy Rot

Polystictus versicolor (L.) Fr. . . . White Spongy Sap Rot
Poria mucida Pers. (=*P. versiporus* Pers.) . White Spongy Rot
Trametes lactinea Berk. . . . . White Sap Rot

Agave sisalana Perrine
Colletotrichum agaves Cav. . . . Anthracnose
Leptosphaeria agaves Syd. and Butler . Leaf Spot

Albizzia lebbek Benth.
Ascochyta saccardiana F. Tassi. . . Brown Spot
Irpex flavus Klotzsch. . . . . White Spongy Sap Rot
Sphaerophragmium acaciae (Cooke) P. Magnus. . . . . Brown Rust

Albizzia procera Benth.
Ganoderma applanatum (Pers.) Pat. . White Sap and Heart Rot

Albizzia stipulata Boivin
Hexagonia discopoda Pat. and Har. . . White Sap Rot
Stereum lobatum Fr. . . . . White Spongy Slash Rot

Allium cepa L. Onion, *Piaz, Vengaiam*
Alternaria palandui Ayyangar . . Leaf Blight
Aspergillus niger van Tiegh. . . . Black Mould
Macrosporium cladosporioides Desm. . Macrosporium Blight
Puccinia porri (Sow.) Wint. . . . Rust

Allium sativum L. Garlic, *Lassan*
Leveillula taurica (Lev.) Arn. . . . Mildew

Aloe vera L. Indian aloes
Uromyces aloes (Cooke) P. Magnus . . Rust

Amarantus blitum L.
Cystopus bliti (Biv.) de Bary . . . White Blister (White rust)

Amarantus gangeticus L. (***A. tristis*** L.) Red sag, *lal sag*
Cystopus bliti (Biv.) de Bary. White Blister (White rust)
Sclerotinia sclerotiorum (Lib.) de Bary. . Stem Rot
Pythium aphanidermatum. (Edson.) Fitzp. Damping off

Amarantus paniculatus L. *Rajgira*
Cystopus bliti (Biv.) de Bary . . . White Blister (White Rust)

Amoora rohituca W. and A.
Fomes geotropus Cke. . . . . Pecky Rot
Trametes lactinea Berk. . . . . White Sap Rot

Amorphophallus campanulatus Bl. Elephant Foot yam *Suran*,
Sclerotium rolfsii Sacc. . . . Corn Rot (Sclerotial Rot)

Anacardium occidentale L. Cashew
Pellicularia salmonicolor (B. & Br.) Dast.
(*Corticium salmonicolor* Berk. and Br.) . Pink Disease

Ananas comosus (L.) Merr. Pineapple, *Ananas*
Asterinella stuhlmanni (P. Henn.) Theiss. . Brown Leaf Spot
Ceratosmella paradoxa (de Seynes) Dade . Soft Rot

Anogeissus latifolia Wall.
Daedalea flavida Lev. . . . . White Spongy Rot
Polyporus gilvus Schw. . . . White Pocket Rot
Trametes persoonii. Fr. . . . . White Spongy Rot
,, *spongipellis* (L.) Lloyd . . Brown Rot

Anogeissus pendula Edgew.
Polystictus hirsutus Fr. . . . . White Spongy Sap Rot

Anona squamosa L. Custard apple, Sugar apple, *sitaphal*
Pellicularia salmonicolor (B. & Br.) Dast.
(*Corticium salmonicolor* Berk. and Br.) . Pink Disease

Apium graveolens L. Celery . .
Cercospora apii Fres. Early Blight
Puccinia apii Desm. . . . . Rust
Septoria apii-graveolentis Dorogin . . Late Blight

Arachis hypogaea L. Pea nut, ground nut, *Chini badam*, *badam*
Cercospora arachidicola Hori . . . Irregular Leaf Spot
Cercospora personata (B. and C.) Ell. and Ev. Tikka
Macrophomina phaseoli (Maubl.) Ashby Dry Root Rot
Sclerotium rolfsii Sacc. Collar Rot

Arecacatechu L. Betel nut, *Supari*
Ceratostomella paradoxa (de Seynes) Dade . Stem Bleeding
Colletotrichum catechu Diedicke . . Anthracnose
Diplodia catechu Syd. and Butler . . Flower Stalk Rot
Ganoderma lucidum (Leys.) Karst. . . Foot Rot
Pestalotia heteronema Sacc. . . . Grey Blight
Phytophthora palmivora Butler . . Kolleroga (Mahati)
Polyporus ostreiformis Berk. . . . Brown Sap Rot
Rosellinia cocoes P. Henn. . . . Collar Rot

Artocarpus chaplasha Roxb.

Daldinia eschscholzii (Ehrenb) Rehm. . Ulawa Superficial White Rot
Pellic. salmonicolor (B. and Br.) Dast. Pink Disease
(*Corticium salmonicolor* Berk. and Br.)

Artocarpus integrifolia L. Jack fruit, *Kathal, Panas*
Pellicularia salmonicolor (B. and Br.) Dast.
(*Corticium salmonicolor* Berk. and Br.) . Pink Disease
Pestalotia clasticola P. Henn. . . . Grey Blight
Phyllostictina artocarpina (Syd. and Butler) Syd. . . . . Leaf Spot
Phytophthora palmivora Butler . . Soft Rot
Rhizopus artocarpi Rac. . . . . Infloresence Rot
Rosellina arcuata Petch . . . . Collar Rot
Septoria artocarpi Cooke . . . . Leaf spot
Sphaerostilbe repens B. and Br. . . Red Root Disease
Ustulina zonata (Lev.) Sacc. . . . Charcoal Rot

Avena spp. Oats, *Jai*
Helminthosporium avenae Eidam . . Leaf Stripe
Puccinia coronata Corda . . . Crown Rust
Puccinia graminis Pers. var. *avenae* Erikss. and P. Henn. . . . . Black Rust
Ustilago avenae (Pers.) Jensen . . . Loose Smut
Ustilago kolleri Wille. . . . . Covered Smut

Bambusa spp. *Bamboo*
Anthostomella bambusae (Lev.) Sacc. . Black Cululm
Balladyna butleri Syd. . . . . Black Spot of Leaf
Daedalea flavida Lev. . . . . White Stringy Rot
Daldinia concentrica (Bolt.) Ces. and de Not. Superficial White Rot
,, *eschscholzii* (Ehrenb.) Rehm. . Superficial White Rot
Dasturella divina (Syd.) Mundkur and kheswala . . . . . Rust
Diatrype chlorosarca Berk. and Br. . . Black Spot of Stem
Diplozythiella bambusina Died. . . Grey Leaf Spot
Eriosphaeria calospora Speg. . . . Black Spot of Sheath
Flamnula dilepis Berk. and Broome . . White Rot
Fomes lividus Kalchbr . . . . White Spongy Rot
,, *pectinatus* Kl. . . . . White Stringy Rot
Ganoderma lucidum (Leyss) Karst. . . White Stringy Rot
Hypoxylon fusco-purpureum (Schw.) Berk. and Curt. Brown Stain of Wood
Hypoxylon perforatum (Schw.) Fr. . . Dark Superficial Rot
Hypoxylon rubiginosum (Pers.) Fr. . . Superficial Cortical Rot
Ionzites adusta Massee . . . . White Stringy Rot

Irpex flavus Kl. . . . . White Stringy Rot
Konradia bambusina Racib. . . . Culumnar Rot
Merulius similis. Berk, and Br. . . White Stringy Rot

Phyllachora bambusae Syd. and Butler . Leaf Spot
,, *malabarensis* Syd. and Butl. . Leaf Spot
,, *shiraiana* Syd. . . . Leaf Spot
Polyporus durus Jungh. . . . . Brown Cubical Rot
Polystictus hirsutus Fr. . . . . White Spongy Rot
Polystictus steinheilianus Berk. and Lev. . White Stringy Rot
Poria diversispora B. and Br. . . . White Stringy Rot
Puccinia gracilenta Syd. and Butler . . Brown Leaf Rust
,, *xanthosperma* Syd. . . Leaf Rust
Sphaerella bambusina Syd. and Butler . Dark Brown Leaf Spot
Trametes cingulata Berk. . . . . White Rot
Trametes persoonii Fr. . . . . White Stringy Rot
Ustilago shiraiana P. Henn. . . . Smut

Basella alba L. Indian spinach, Malabar night shade, *Poi*
Benincasa hispida Cogn. . . . . Ash Gourd
Erysiphe cichoracearum DC. . . . Mildew

Bauhinia acuminata Linn.
Uromyces vestergreni Syd. (*Uromyces verruculosus* B. and Br.) . . . . Leaf Rust

Bauhinia purpurea Linn.
Phyllosticta bauhiniae Cke. . . . Leaf Spot

Bauhinia retusa Ham.
Ganoderma applanatum (Per.) Fr. . . White Sap and Heart Rot
Irpex flavus Kl. . . . . White Sap Rot

Bauhinia tomentosa Linn.
Uromyces vestergreni Syd. . . Leaf Rust

Bassia latifolia Roxb.
Polystictus steinheilianus Berk. and Lev. . White Spongy Rot

eta vulgaris L. Beet chukander
Cercospora beticola Sacc. . . . . Leaf Spot
Puccinia betae-bengalensis Mundkur and Thirumalachar . . . . . Rust

Betula utilis Don.
Polyporus secernibilis Berk. . . . White Spongy Rot
Polystictus hirsutus Fr. . . . . White Spongy Sap Rot

Bombax malabaricum DC.

Cladotrichum foliicola (Neissl) Ferro	Leaf Spot
Polyporus friabilis Bose	White Spongy Rot
Trametes persoonii Fr.	White Spongy Rot

Borassus flabellifer L. Toddy palm, *Palmyra*

Ceratostomella paradoxa (de Seynes) Dade	Stem Bleeding
Exosporium palmivorum Sacc.	Leaf Splitting
Graphiola borassi Syd. and Butler	Pin Head Spot
Pestalotia palmarum Cooke	Grey Blight
Phytophthora palmivora Butler	Bud Rot

Boswellia serrata Roxb.

Polystictus leoninus Klotzsch	White Spongy Rot

Brassica spp. Mustard, Indian rape, Black mustard, etc. *Sarson, Toria Rai,*

Alternaria brassicae (Berk.) Sacc.	Pod Blight
Cystopus candidus (Pers.) Lev.	White Blister (White Rust)
Erysiphe polygoni DC.	Mildew
Peronospora brassicae Gaumann	Downy Mildew
Urocystis brassicae Mundkur	Root Gall Smut

Brassica oleracea L. var. *capitata* L. Cabbage, *band gobi*

Mycosphaerella brassicola (Duby) Lindau	Ring Spot
Plasmodiophora brassicae Woronin	Club Root
Xanthomonas campestris (Pamm) Dowson	Black Rot

Cajanus cajan (L.) Millsp.

Diplodia cajani Raychaudhuri	Stem Canker
Fusarium udum Butler	Wilt
Ganoderma lucidum (Leyss.) Karst.	Collar Rot
Uredo cajani Syd.	Rust

Camellia sinensis (L.) Kuntz, Tea, *Chaya*

Asterina camelliae Syd. and Butler	Black Blight
Botryodiplodia theobromae Patouill	Root Rot
Capnodium theae Boedijn	Sooty Mould
Colletotrichum camelliae Massee	Brown Blight
Corticium repens Berk.	Thread Blight
Exobasidium vexans Massee	Blister Blight
Fomes lamaoensis (Murr.) Sacc. and Trott.	Brown Root Disease
Fomes lignosus Klotsch	Brown cubical Rot
Ganoderma applanatum (Pers.) Patouill	White Rot
Ganoderma lucidum (Leyss.) Karst	Foot Rot
Nectria cinnabarina (Tode) Fr.	Canker

Pellicularia salmonicolor (B.and Br.) Dast. Pink Disease
Pestalotia theae Sawada . . . . Grey Blight
Rosellinia arcuata Petch . . . . Stump Rot
Rosellinia bunodes (Berk. and Br.) Sacc. . Stump Rot
Sphaerostilbe repens Berk. and Br. . . Red Root Rot
Ustulina zonata (Lev.) Sacc. . . . Charcoal Rot

Canavalia ensiformis DC. Sword bean
Colletotrichum capsici (Syd.) Butler and Bisby . . . . . Anthracnose

Cannabis sativa L. Hemp, *Bhang*, *Ganja*, *Charash*
Cercospora cannabina Wakef. . . . Leaf Blight
Septoria cannabis (Lasch.) Sacc. . . Leaf Spot

Capsicum annuum L. Red pepper, Chillies, *Mirach*
Cercospora capsici Heald and Wolf . . Leaf Spot
Colletotrichum capsici (Syd.) Butler and Bisby . . . . . Anthracnose
Glomerella cingulata (Stonem.) Spauld. and v. schrenk . . . . . Ripe Rot
Leviellula taierica (Lev.) Arnaud. . . Mildew
Pythium aphanidermatum (Eds.) Fitz. . Damping off
Sclerotium rolfsii Sacc. . . . . Collar Rot

Capsicum frutescens L. Chilli
Leveillula taurica (Lev.) Arnaud . . Mildew

Carica papaya L. *Papaw*, *Papaya*, *Papita*
Pythium aphanidermatum (Eds.) Fitz. . Stem Rot

Carissa carandas L. *Caronda*, *Karavand*
Meliola carissae Doidge . . . . Sooty Mould

Carthamus tinctorius L. Safflower, *Kusumb*, *Kardi*
Erysiphe cichoracearum DC. . . . Mildew
Puccinia carthami (Hutzelm.) Corda . Rust

Castanea sativa Mill. Sweet or Spanish Chestnut
Endothia p. parasitca (Mutr.) P.J. & H.W. Anderson . . . . . Chestnut Blight

Cassia fistula L.
Trametes incerta (Currey) Cke. . . Brown Pocket Rot

Cassia javanica Vell.
Fomes senex Nees and Mont. . . White Sap and Heart Rot

Cassia Javanica Vell.—*contd.*

Ganoderma applanatum (Pers.) Pat.	White Sap Rot
Ganoderma lucidum (Leyss.) Karst.	White Sap and Heart Rot

Cassia siamea Lamk.

Ganoderma lucidum (Leyss.) Karst.	White Sap and Heart Rot

Casuarina equisetifolia L.

Hexagonia thwaitesii Berk.	White Sap Rot
Trichosporium vesiculosum Butler	Black Blister Bark Disease

Casuarina montana Leschen-ex Miq.

Hexagonia discopoda Fr.	White Sap Rot

Casuarina muricata Roxb.

Trichosporium vesiculosum Butler	Black Blister Bark Disease

Cedrela toona Roxb.

Fomes senex Nees and Mont.	White Sap and Heart Rot
Ganoderma appalanatum Pat.	White Sap and Heart Rot
Polyporus gilvus Schw.	White Spongy Sap Rot
Polystictus xanthopus Fr.	White Spongy Rot

Cedrus deodara Loudon

Fomes annosus Fr.	Annosus Butt Rot
Lenzites sepiaria (Wulf.) Fr.	Brown Cubical Rot (Dry Rot)
,, *striata* Swartz.	Brown Cubical Rot (Dry Rot)
,, *sub-ferruginea* Bark.	Brown Cubical Rot (Dry Rot)
Peridermium cedri (Barcl.) Sacc.	Needle Rust
Polystictus amorphus Fr.	Brown Spongy Sap Rot
,, *abietinus* (Dicks.) Fr.	Pitted Sap Rot
Trametes mollis Fr.	White Spongy Rot
,, *pini* (Brot.) Fr.	Red Ring Rot

Celtis australis Linn.

Fomes fomentarius (L.) Fr.	Heart Rot
Polyporus adustus (Willd.) Fr.	White Spongy Rot

Chenopodium album L. Pigweed, *Bathua*

Cercospora chenopodii Fr.	Leaf Blight
Peronospora effusa (Grev.) Rabenh.	Mildew
Peronospora variabilis Gaumann	Mildew
Phyllosticta ambrosioides Thum.	Leaf Spot

Chickrassia tabularis Adr. Juss.

Fomes senex Nees and Mont.	White Sap and Heart Rot

Chrysanthemum Spp.

Septoria chrysanthemella Allesch.	Leaf Blotch
Puccinia chrysanthemi Roze.	Rust
Phyllosticta chrysanthemi Ell. et. Dearn.	Leaf Spot

Cicer arietinum L. Chick pea, Bengal gram, *chana*

Macrophomina phaseoli (Maubl.) Ashby	Root Rot (Dry Wilt)

Cicer arietinum L. Chick pea, Bengal gram, *chana—contd.*

Mycosphaerella rabiei Kovachevs (*Ascochyta rabiei* (Pass.) Trott)	Blight
Operculella padwickii Kheswalla	Foot Rot
Rhizoctonia solani Kuhn	Brown Root Rot
Sclerotinia sclerotiorum (Lib.) de Bary	Stem Rot
Uromyces ciceris—arietini (Greg.) Jacz. and Boyer	Rust

Cinchona spp.

Diplodia sp.	Stem Canker
Fomes lamaoensis (Murr.) Sacc. and Trott.	Brown Root Rot

Cinnamomum camphora F. Nees. Camphor tree

Fomes pectinatus Klotzsch	White Rot

Cinnamomum cecicodaphane Meissn.

Ganoderma applanatum Pat.	White Sap and Heart Rot

Cinnamomum tamala Nees

Exobasidium cinnamomi Petch	Leaf Spot

Citrullus vulgaris Schrad, Water melon, *Turbuz*

Erysiphe cichoracearum DC	Mildew

Citrus aurantifolia (Christm.) Swingle, Lime fruit, *Kagzii nimboo*

Meliola butleri Syd.	Sooty Mould
Phytomonas citri (Hasse) Bergey *et al*	Canker

Citrus aurantium L. Sour, Bitter, Saville Orange

Colletotrichum gloeosporioides Penzig	Anthracnose
Daldinia eschscholzii (Ehrenb.) Rehm.	Charcoal Rot
Meliola camelliae (Catt.) Sacc.	Sooty Mould
Oidium tingitanium Carter	Mildew
Pellicularia salmonicolor (B. and Br.) Dast. (*Corticium salmonicolor* Berk. and Br.)	Pink Disease
Phytophthora palmivora Butler	Leaf and Fruit Rot
Phytophthora parasitica Dastur	Leaf and Fruit Rot
Sphaceloma fawcetti Jenkins	Scab

Citrus limonis Osbeck, Lemon, *Khatti*,

Meliola citricola Syd.	Sooty Mould

Citrus medica L. Citron, *Mahalung*,

Colletotrichum gloeosporioides Penzig	Anthracnose
Melanomma citricola Syd. and Butler	Black Bark Spot

Citrus nobilis Lour. *Tangerine, Sangara, Kamla*

Meliola butleri Syd.	Sooty Mould
Phytophthora palmivora Butler	Leaf Fall and Fruit Rot

Citrus sinensis Osbeck, Sweet orange, *Mosambi*

Colletotrichum gloeosporioides Penz.	Anthracnose
Meliola citricola Syd.	Sooty Mould
Phytophthora palmivora Butler	Leaf Fall and Fruit Rot
Septobasidium citricolum Saw.	Black felt

Coccinia indica (Naud) W. and A., *Tondli*

Erysiphe cichoracearum DC.	Mildew
Oidium erysiphoides Fr.	Mildew
Puccinia cephalandrae-indicae Syd.	Rust

Cocos nucifera Linn. Coconut palm, *Narel Khopra*

Ceratostomella paradoxa (De Seynes) Dade	Stem Bleeding
Ganoderma lucidum (Leyss.) Karst	Root Rot
Gliocladium roseum Bain	Leaf Rot
Helminthosporium halodes Drech	Leaf Rot
Pestalotia palmarum Cke.	Grey Blight
Phytophthora palmivora Butl.	Bud Rot
Phytophthora palmivora Butl. (=*P. arecae* (Colem.) Pethybridge)	Bud Rot Nut Fall

Coffea arabica L. coffee

Capnodium brasiliense Puttemans	Sooty Mould
Cercspora coffeicola Berk. and Cooke	Brown Eye Spot
Colletotrichum coffeanum Noack	Brown Blight
Corticium koleroga (Cooke) V. Hoehn	Black Rot
Fomes lamoensis (Murr.) Sacc. and Trott	Brown Root Disease
Hemileia vastatrix Berk. and Br.	Rust (leaf)
Mycosphaerella coffeicola Cke.	Leaf Spot
Pellicularia salmonicolor (B. and Br.) Dast.	Pink Disease

Colocasia esculenta (L.) Schott.

Phytophthora colocasiae Rac.	Blight
Selerotium rolfsii Sacc.	Corn Rot

Corchorus capsularis L. Jute

Diplodia corchori Syd.	Canker
Macrophomina phaseoli (Maubl.) Ashby	Shredding Disease
Oidium sp.	Mildew

Corchorus olitorius L. Jute

Diplodia corchori Syd.	Canker
Macrophomina phaseoli (Maubl.) Ashby	Shredding Disease
Oidium sp.	Mildew

Cordia oblique Willd.

Polyporus secernibilis Berk.	White Spongy Rot

Coriandrum sativum L. Coriander,

Dhania Erysiphe polygoni DC.	Mildew
Protomyces macrosporus Unger	Tumour

Corylus colurna Linn.

Polystictus versicolor (L.) Fr.	White Spongy Sap Rot
Pucciniastrum coryli Kom.	Rust

Cotoneaster bacillaris Wall.

Fomes conchatus (Pers.) Fr.	White Sap and Heart Rot
Gymnosporangium distortum Arth. and Cummin.	Leaf and Twig (Reddish brown) Rust
Polystictus versicolor (L.) Fr.	White Spongy Sap Rot

Crotalaria juncea L. Sann-hemp

Macrophomina phaseoli (Maubl.) Ashby	Dry Wilt, Root Rot
Oidium erysiphoides Fr.	Mildew
Rhizoctonia solani Kuhn	Brown Root Rot
Uromyces decoratus Syd.	Rust

Cucumis melo L. Sweet melon, *Khurbuja*

Erysiphe cichoracearum DC.	Mildew
Erysiphe polygoni DC.	Mildew
Pseudoperonospora cubensis (Berk. and Curt.) Rost.	Downy Mildew

Cucumis melo L. var. *momoridica*

Phythium aphanidermatum (Eds.) Fitz.	Fruit Rot

Cucumis melo L. var. *utilissimus* Roxb.

Pseudoperonospora cubensis (Berk. and Curt.) Rost.	Downy Mildew

Cucurbita maxima Duetr., Pumpkin Squash

Pseudoperonospora cubensis (Berk. and Curt.) Rost.	Downy Mildew
Sphaerotheca humuli (DC.) Burr. var. *fuliginea* (Sch.) Salm.	Mildew

Cucurbita pepo L. Vegetable marrow, *Kumra*

Cercospora cucurbitae Ell. and Ev.	Leaf Spot

Cuminum cyminum L. Cumin, *Jeera*

Erysiphe polygoni DC.	Mildew

Cupressus torulosa Don.

Gymnosporangium cunninghamianum Barcl.	Rust

Curcuma longa L., Turmeric, *Haldi*

Colletotrichum curcumae (Syd.) Butler and Bisby	Anthracnose
Taphrina maculans Butler	Leaf Spot

Cyamopsis psoraloides DC. Cluster bean, *Guar*

Alternaria brassicae (Berk.) Sacc.	Leaf Spot

Cymbopogon martini W. Wats., Ginger grass, Russa grass

Sorosporium wildemanianum P. Henn.	Smut

Dalbergia latifolia Roxb.

Polystictus steinheilianus Berk. and Lev.	White Spongy Sap Rot

Dalbergia latifolia Roxb.—*contd.*

Schizophyllum commune Fr.	White Superficial Rot
Trametes lactinea Berk.	White Spongy Sap Rot
Trametes persoonii Fr.	White Spongy Rot

Dalbergia sissoo Roxb. *Seesham, Tali*

Cercospora sissoo Syd.	Leaf Spot
Daedalea flavida Lev.	White Spongy Rot
Diplodia dalbergiae Diedicke	Twig Blight
Fomes lucidus (Leyss.) Fr.	White Sap and Heart Rot
Fomes rimosus Berk.	Spongy Yellow Heart Rot
Ganoderma applanatum Pat.	White Sap and Heart Rot
Hypoxylon investiens (Schw.) Berk.	Grey Bark Rot
Hypoxylon rubiginosum (Pers.) Fr.	Superficial White Rot
Irpex flavus Kl.	White Sap Rot
Phyllachora dalbergiae Niessl.	Black Leaf Spot
Phyllactinia subspiralis (Salm.) Blumer	Mildew
Polyporus gilvus Schwein.	White Sap Rot
Uredo sissoo Syd.	Yellow Rust
Uromyces achrous Syd.	Brown Rust

Daucus carota L. Carrot, *Gajar*

Cercospora apii Tres. Var. *carotae* Pas	Grey Leaf Spot
Erysiphe polygoni DC.	Mildew

Dendrocalamus strictus Nees

Dasturella bambusina Mund. and Kheshwalla	Rust

Deutzia staminea Br.

Aecidium tandonii Mitter	Leaf Rust
Uredo deutziae Barcley	Leaf Rust

Diospyros melanoxylon Roxb.

Stereum lobatum Fr.	White Spongy Slash Rot

Diospyros montana Roxb.

Meliola diospyri Syd.	Black Leaf Spot

Dipterocarpus macrocarpus Zipp. ex Miq. *Ganoderma applanatum* (Pers.) Pat. — White Sap and Heart Rot

Dolichos lablab L. hyacinth bean, *avari, sem*

Cercospora dolichi Ell. and Ev.	Leaf Spot
Leveillula taurica (Lev.) Arnaud var. *macrospora* Uppal, Patel and Kamat	Mildew
Neocosmospora vasinfecta E. F. Smith	Dry Root Rot
Uromyces appendiculatus (Pers.) Link.	Rust

Echinochloa frumentacea Link Japanese barnyard millet

Ustilago crusgalli Tracy and Earle	Shoot smut
„ *panici-frumentacei* Bref.	Smut

Elaeocarpus tuberculatus Roxb.

Polystictus flabelliformis Kl.	White Spongy Rot

Elaeodendron glaucum Pers.

Fomes rimosus Berk.	Spongy Yellow Heart Rot

Elettaria cardamomum Maton, lesser cardamom, Malabar cardamom, *Chota elaichi*

Pythium coplectens Braun	Rhizome Rot
Pythium aphanidermatum (Edson) Fitzpatrik	Rhizome Rot

Eleusine coracana Gaertn., Finger millet, *Ragi, Nachni*

Acrothecium lunatum Wakker	Leaf Spot
Helminthosporium leucostylum Drechs.	Leaf spot
Helminthosporium nodulosum Berk. and Curt	Leaf spot
Helminthosporium tetramera McKinney	Leaf Spot
Piricularia eleusine Cav.	Blast
Sclerotium rolfsii Sacc.	Root Rot

Ephedra intermedia Schrenk and C.A. Mey.

Peridermium ephedrae Cke.	Rust

Ephedra vulgaris Rich.

Peridermium ephedrae Cke.	Rust

Eruca sativa Mill. Rocket salad, *Tara-mira*

Cystopus candidus (Pers.) Lev.	White Blister
Peronospora parasitica (Pers.) de Bary	Downy Mildew

Erythrina indica Lam.

Polyporus anebus Berk.	White Spongy Sap Rot

Euchlaena mexicana Schrad. *Teosinte*

Sclerospora andropogonis sorghi (Kulkarni) Mundkur	Downy Mildew

Eugenia cumini (L.) Merr., Black plum, *Jamun*

Capnodium sp.	Sooty Mould
Diplodia variispora Diedicke	Sooty Mould
Meliola cladotricha Lev.	Sooty Mould

Eugenia jambolana Lam. *Jamun*

Trametes persoonii Fr.	White Spongy Rot

Eugenia jambos L. Rose apple, *Gulab jamb*
Capnodium eugeniarum Cooke . . Sooty Mould

Fagopyrum esculentum Moench. Buck-wheat
Puccinia fagopyri Barclay . . . Rust
Sphacelotheca fagopyri Syd. and Butler . Smut

Ficus bengalensis Linn.
Trametes persoonii Fr. . . . . White Spongy Rot

Ficus carica L. Fig, *Anjir*
Cerotelium fici (Cast.) Arthur . . . Rust

Ficus glomerata Roxb.
Cerotelium fici (Cast.) Arth. . . . Foliage Rust

Ficus religiosa L. *Pipul, Ashwatha*
Catacauma infectorium (Cooke) Theiss. and Syd. . . . . Tar Spot
Catacauma repens (Corda) Theiss. and Syd. Tar spot
Cerotelium fici (Cast.) Arthur . . . Rust
Polyporus grammocephalus Berk. . . White Stump Rot
Polystictus flabelliformis Klotsch . . White Creamish Spongy Rot

Ficus venjamica Linn.
Capnodium anonae Pat. . . . . Sooty Mould

Foeniculum vulgare Mill. Fennel, *Sonf*
Cercospora foeniculi P. Magnus . . Blight
Leveillula taurica (Lev.) Arnaud . . Mildew

Fraxinus excelsior Linn.
Fomes fomentarius (L.) Fr. . . . Heart Rot

Glochidion assamicum Hk. f.
Polyporus weberianus Bred. and P. Henn. . White Rot

Glycine max (L.) Merr., Soya bean
Peronospora trifoliorum de Bary . . Downy Mildew
Phyllosticta glycines Thuem . . . Leaf Spot

Gossypium Spp. Cotton, *kapas*
Alternaria macrospora Zimm. . . . Zonate Leaf Spot
Ascochyta gossypii Syd. . . . . Leaf Spot
Cercospora gossypina Cooke . . . Leaf Spot
Cerotelium desmium (Berk. and Br.) Arthur Rust
Chaetomium amphitricum Corda . . Anthracnose
Colletotrichum indicum Dastur . . . Anthracnose
Macrophomina phaseoli (Maubl.) Ashby . Dry Root Rot
Nematospora coryli Peglion . . . Internal Root Rot
Nematospora gossypii Ashby and Nowell . Internal Root Rot

Gossypium Spp. Cotton, *kapas—contd.*	
Nematospora nagpuri Dastur	Internal Root Rot
Ramularia areola Atkinson	Areolate Mildew
Rhizoctonia solani Kuhn	Brown Root Rot
Xanthomonas malvacearum (Smith) Dowson	Angular Leaf Spot
Grevillea robusta A. Cunn.	
Trametes cingulata Berk.	White Spongy to Fibrous Rot
,, *persoonii* Fr.	White Spongy Rot
Grewia tiliaefolia Vahl.	
Ganoderma applanatum (Pers.) Pat.	White Sap and Heart Rot
Hardwickia pinnata Roxb.	
Schizophyllum commune Fr.	White Superficial Rot
Helianthus annus L. Sunflower	
Puccinia helianthi Schw.	Rust
Sclerotinia sclerotiorum (Lib.) Massee	Stem Rot
Heritiera minor Roxb.	
Haxagonia apiaria Pers.	White Spongy Rot
Hevea brasiliensis Muell. Arg., Para rubber	
Botryodiplodia clasticae Petch	Die Back
Botryodiplodia theobromae Patouill	Die Back
Colletotrichum heveae Petch	Leaf Spot
Fomes lamaoensis (Murr.) Sacc. and Trott.	Brown Root Rot
Helminthosporium heveae Petch	Birds Eye Spot
Nectria diversispora Petch	Canker
Oidium heveae Stein.	Mildew
Pellicularia salmonicolor (B. & Br.) Dastur (*Corticium salmonicolor* Berk. and Br.)	Pink Disease
Phytophthora palmivora Butler	Pod Rot, Leaf fall, Canker, Black Thread
Polystictus occidentalis (Klotzsch) Fr.	White Rot of Scion
Polystictus persoonii Fr.	White Spongy Rot
Sphaerella heveae Petch	Rim Blight
Sphaerostilbe repens Berk. & Broome	Red Root Disease
Ustulina zonata (Lev.) Sacc.	Charcoal Butt Rot, Charcoal Rot
Hibiscus cannabinus L. Deccan hemp, *Ambadi, Bimilapatan*	
Cercospora hibisci Tracy and Earle	Leaf Spot
Diplodia hibiscina Cke. and Ell.	Stem Rot
Macrophomina phaseoli (Maubl.) Ashby	Dry Root Rot
Phyllosticta hibisci Peck	Leaf Blight
Hibiscus esculentus L. Lady's finger *Okra, Bhindi*	
Cercospora hibisci Tracy and Earle	Leaf Spot

Hibiscus esculentus L. Lady's finger., *Okra, Bhindi*—contd.

Colletotrichum hibisci Poll.	Anthracnose
Erysiphe cichoracearum DC	Mildew
Macrophomina phaseoli (Maubl.) Ashby	Dry Root Rot

Hibiscus rosa sinensis L. Shoe flower

Choanephora infundibulifera (Currey) Cunningham	Wet Rot

Hopea parviflora Bedd.

Fomes lamaoensis (Murr.) Sacc. and Trott.	Honey combed Rot
Trametes spongipellis Lloyd	White Pocket Rot

Hopea wightiana Wall.

Fomes badius Berk.	Spongy Heart Rot or Butt Rot

Hordeum vulgare L. Barley, *jau*

Erysiphe graminis DC. var. *hordei* Lev.	Mildew
Helminthosporium gramineum Rabenh.	Leaf Stripe
Helminthosporium sativum P. K. et B.	Foot Rot
Helminthosporium teres Sacc.	Net blotch
Puccinia anomala Rostr.	Brown or twany Rust
Puccinia glumarum (Schm.) Erikss. and Henn.	Yellow Rust
Puccinia graminis Pers.	Black Rust
Ustilago hordei (Pers.) Lagerh.	Covered Smut
Ustilago nuda (Jens.) Rostr.	Loose Smut

Ipomoea batatas (L.) Lam. Sweet potato, *Ratali, Mitha alu*

Cercospora batatae Zimm.	Leaf spot
Cystopus ipomoeae—panduratae (Schw.) Steven and Swing	White Blister
Rhizoctonia solani Kuhn	Black Rot.

Jacaranda ovalifolia R. Br.

Polystictus hirsutus Fr.	White Spongy Rot

Jasminum arborescens Roxb.

Dendrophoma jasmini Syd.	Stem Blight
Fusicladium butleri Syd.	Leaf spot
Microdiplodia jasmini Syd.	Stem Blight
Uromyces hobsoni Vize.	Leaf and Stem Rust

Jasminum auriculatum Vahl.

Meliola jasminicola P. Henn.	Sooty Mould

Jasminum grandiflorum Linn.

Uromyces hobsoni Vize.	Leaf and Stem rust

Jasminum malabaricum weight

Asterina spissa Syd.	Leaf Mould
Chaconia butleri Syd.	Rust
Uromyces hobsoni Vize	Leaf and Stem Rust

Jasminum officinale *Linn.*

Uromyces hobsoni Vize	Leaf and Stem Rust

Jasminum pubescens Willd.

Uromyces comedens Syd.	Leaf Rust

Jasminum ritchiei Clarke.

Hemileia jasmini Krishnamurthy and Rangaswami	Rust

Jasminum spp.

Corticium koleroga (Cooke) V. Hoehnel	Black Rot
Meliola jasminicola P. Henn.	Sooty Mould
Phyllactinia corylea (Pers.) Karst.	Mildew
Uromyces hobsoni Vize	Rust

Juglans regia L. Walnut, *Akhrot*

Marsonia juglandis (Lib.) Sacc.	Blotch
Microstroma juglandis (Bereng.) Sacc.	Downy Leaf Spot
Phyllactinia corylea (Pers.) Karst.	Mildew

Lagenaria leucantha (Dutch.) Rusby Calabash gourd, *Kaddu*

Colletotrichum lagenarium (Pass.) Ell. and Halst.	Anthracnose
Synchytrium rytzii Syd.	Leaf Blister

Lagerstroemia lanceolata Wall.

Daedalea flavida Lev.	White Spongy Rot
Fomes durissimus Lloyd	White Stump Rot
Rhytisma lagerstroemiae Rabenh.	Tar Spot

Lagerstroemia parviflora Roxb.

Fomes durissimus Lloyd	White Stump Rot
,, *fastuosus* Lev.	Dark Brown Heart Rot
,, *pectinatus* Kl.	White Spongy Rot
,, *rimosus* Berk.	Spongy Yellow Heart Rot
Polyporus gilvus (Schw.) Fr.	White Pocket Rot
Rhytisma lagerstroemiae Rabenh.	Tar Spot
Trametes incerta (Currey) Cke.	Grey Heart Rot

Lathyrus sativus L. Grass pea, *Khesari, Lang*

Oidium erysiphoides Fr.	Mildew
Peronospora lathyri-palustris Gaumann	Downy Mildew
Uromyces fabae (Pers.) de Bary	Rust

Lawsonia inermis L. Indian privet, *Henna, Mehdi*

Corticium koleroga (Cooke) V. Hoehn.	Black Rot

Lens esculenta *Moench*, lentil, *Masur*

Uromyces fabae (Pers.) de Bary	Rust

Linum usitatissimum L. Linseed, *Alsi*

Fusarium lini Bolley	Wilt
Melampsora lini (Pers.) Lev.	Rust

Luffa acutangula *Roxb. Ghoslae, Jhinga*

Pseudoperonospora cubensis (Berk. and Curt.) Rost.	Downy Mildew
Pythium aphanidermatum (Eds.) Fitz.	Fruit Rot

Luffa aegyptiaca Mill.

Pythium aphanidermatum (Eds.) Fitz.	Fruit Rot

Luffa cylindrica *Roem. loofah*

Pseudoperonospora cubensis (Berk. and Curt.) Rost	Downy Mildew
Pythium aphanidermatum (Eds.) Fitz.	Fruit Rot

Lycopersicum esculentum Mill. Tomato

Cladosporium fulvum Cke.	Leaf Mould
Erysiphe polygoni DC	Mildew
Fusarium bulbigenum Cooke and Massee var. *Lycopersici* (Brushi) Wr. and Reink.	Fusarium Wilt
Phytophthora infestans (Mont.) de Bary.	Blight
Phytophthora parasitica Dastur	Buck Eye Rot

Madhuca latifolia (Roxb.) McBride, *Mahua*

Polystictus steinheilianus Berk. and Lev.	White Sap Rot of Stump
Uromyces echinulatus Niessl.	Rust

Mallotus philippinensis, Muell. Arg.

Fomes conchalus (Pers.) Gillet.	White Sap and Heart Rot
„ *rimosus* Berk.	Spongy Yellow Heart Rot
Hexagonia discopoda Pat and Har.	White Sap Rot
Phyllosticta marmorata Cke.	Brown Leaf Spot
Polyporus adustus (Willd.) Fr.	White Spongy Rot
Polystictus hirsutus Fr.	White Spongy Sap Rot
Polystictus steinheilianus Berk.	White Spongy Rot
Stereum hirsutum (Willd.) Fr.	White Spongy Slash Rot

Mangifera indica L. Mango, *Amb.*

Botryodiplodia theobromae Patouill	Die Back
Capnodium ramosum Cooke	Sooty Mould
Dothiorella mangiferae Syd.	Stem end Rot
Fomes conchatus (Pers.) Gillet	White Sap and Heart Spongy Rot
Ganoderma applanatum (Pers.) Pat.	White Rot
Glocosporium mangiferae Syd.	Anthracnose
Gloeosporium raciborskii P. Henn.	Anthracnose
Hexagonia discopoda Patouill and Har.	White Sap and Heart Rot
Meliola mangiferae Earle	Sooty Mould
Pellicularia salmonicolor (B. & Br.) Dast. (*Corticium salmonicolor* Bark. and Br.)	Pink Disease

Mangifera indica L. Mango Amb.—*contd.*	
Pestalotia mangiferae P. Henn.	Grey Blight
Phyllosticta mortoni Fair.	Leaf Blight
Physalospora rhodina (Berk. and Curt.) Cooke	Leaf Blight
Polyporus gilvus Schwein.	White Pocket Rot
Polystictus persooni Fr.	White Spongy Rot
Rhinocladium corticolum Mass.	Black Bark
Schizophyllum alneum (L.) Schroet.	Sap Rot
Manihot utilissima *Pohl*, Tapioca, *Cassava*	
Cercospora henningsii Allesch.	Leaf Spot
Medicago sativa L. Lucerne, Alfalfa	
Helicobasidium purpureum (Tul.) Patouill	Violet Root Rot
Leveillula taurica (Lev.) Arnaud.	Mildew
Peronospora aestivalis Syd.	Downy Mildew
Pseudopeziza medicaginis (Lib.) Sacc.	Leaf Spot
Uromyces striatus Schroet.	Rust
Urophlyctis alfalfae (Lagerh.) Magnus	Crown Wart
Melia azadirachta Linn., *Neem*	
Cercospora subsessilis Syd.	Leaf Spot
Fomes sanex Nees and Mont.	White Sap and Heart Rot
Polyporus gilvus Schwein. f. *lichnoides*	White Spongy Rot
Melilotus alba *Desr* White sweet clover	
Erysiphe polygoni DC.	Mildew
Peronospora meliloti Syd.	Downy Mildew
Mentha longifolia (L.) Hudson, horse mint *Pudina*,	
Puccinia menthae Pers.	Rust
Mesua ferrea Linn.	
Fomes dochmius B. and Br.	Brown Cubical Rot
Ganoderma lucidum (Leyss) Karst.	White Sap and Heart Rot
Momordica charantia L. Bitter gourd *Karela*	
Cercospora momordicae McRae	Leaf Spot
Morus alba L. White mulberry, *Shehtut*	
Aecidium mori Barclay	Rust
Cytospora atra (Bon.) Sacc.	Bronze Canker
Diplodia butleri Syd.	Stem Rot
Ganoderma applanatum (Pers.) Patouill.	White Sap and Heart Rot
Phleospora mori (Lev.) Sacc.	Leaf Spot
Phyllactinia corylea (Pers.) Karst.	Mildew
Thyrostroma mori (Nomura) V. Hoehn.	Twig Blight
Trametes badia (Berk.) Cooke	Butt Rot

Murraya koenigii Spreng., Curry leaf tree

Fomes pectinatus Klotszch	White Sap Rot

Musa spp.

Fusarium oxysporum Schl., var. *cubense* (E.F.S.) Wr. and Reink	Wilt
Helminthosporium torulosum (Syd.) Ashby	Black Tip
Macrophoma musae (Cke.) Berk.	Black Finger

Nicotiana spp.

Alternaria longipes (Ell. and Ev.) Mason	Early Blight
Cercospora nicotianae Ell. and Ev.	Frog Eye Spot
Erysiphe cichoracearum DC.	Mildew
Fusarium oxysporum Schl., Var. *nicotianae* Johnson	Wilt
Helminthosporium infectoria Fuckel	Leaf Spot
Phytophthora parasitica Dastur var. *nicotianae* Tucker	Black Shank
Pythium aphanidermatum (Eds.) Fitz.	Damping Off
Pythium de Baryanum Hesse	Damping Off
Rhizoctonia solani Kuhn.	Stem Rot

Odina wodier Roxb.

Cerotelium lanneae (V. Hoehn.) Arth.	Brown Leaf Rust
Meliola geniculata Syd. and Butler.	Leaf Spot
Phakopsora odinae Mundkur.	Rust

Oryza sativa L. Paddy Rice

Cercospora oryzae Miyake	Leaf Spot
Entyloma oryzae Syd.	Leaf Smut.
Ephelis oryzae Syd.	Udbatta Disease
Fusarium moniliforme Sheldon	Fusarium Foot Rot
Helminthosporium oryzae Breda de Haan	Sesame Leaf Blight
Phoma glumarum Ell. and Tr.	Glume Blight
Piricularia oryzae Cav.	Blast
Neovossia horrida (Tak.) Padwick & Azmatullah Khan	Bunt
Ustilaginoidea virens (Cooke) Tak.	False Smut

Ougeinia dalbergioides Benth.

Asterostromella rhodospora Wakef.	White Fibrous Rot
Trametes lactinea Berk.	White Sap Rot

Panicum miliare Lamk. Little millet,

Sava Uromyces linearis Berk. and Br.	Rust

Papaver somniferum L. Opium poppy, *Aphim*

Erysiphe polygoni DC.	Mildew
Peronospora arborescens (Berk.) de Bary	Downy Mildew

Paspalum scrobiculatum L. *Kodra, Kodon*

Sorosporium paspali McAlpine	Smut
Uredo paspali-scrobiculati Syd.	Rust

Pennisetum typhoides Stapf and Hubbard. Bulrush millet, Pearl millet, *Bajri*

Acrothecium penniseti Mitra	Leaf Spot
Puccinia penniseti Zimmerm.	Rust
Sclerospora graminicola (Sacc.) Schroter	Downy Midew
Tilletia ajrekari Mundkur	Bunt
Tolyposporium penicillariae Bref.	Smut
Tolyposporium senegalense Speg.	Smut

Phaseolus aconitifolius Jacq. Moth bean, *Moth*

Cercospora cruenta Sacc.	Leaf Spot
Cercospora dolichi Ell: and Ev.	Leaf Spot
Sphaerotheca humuli (DC.) Burr. Var. *fuliginea* (Schlecht.) Salmon	Mildew

Phaseolus aureus *Rexb.* Green gram, *Mung*

Ascochyta phaseolorum Sacc.	Blight
Cercospora cruenta Sacc.	Leaf Spot
Cercospora dolichi Ell .and Ev.	Leaf Spot
Erysiphe polygoni DC.	Mildew
Macrophomina phascli (Maubl.) Ashby	Dry Root Rot
Uromyces appendiculatus (Pers.) Link.	Rust

Phaselous lunatus L. Lima bean, *Lobia*

Macrophomina phaseoli (Maubl.) Ashby	Dry Root Rot

Phaseolus mungo L. Black gram, *Urid*

Cercospora dolichi Ell. and Ev.	Leaf Spot
Uromyces appendiculatus (Pers.) Link.	Rust

Phaseolus vulgaris L. French bean

Ascochyta phaseolorum Sacc.	Leaf Blotch
Cercospora cruenta Sacc.	Leaf Spot
Colletotrichum lindemuthianum (Sacc. and Magn.) Br. et Cav.	Anthracnose
Uromyces appendiculatus (Pers.) Link	Rust

Phoebe goalparensis Bonsum

Polyporus gilvus Schwein.	White Pocket Rot
Trametes parsoonii Fr.	White Spongy Rot
Trametes serpens Fr.	White Spongy Rot

Phoenix dactylifera L. Date palm, *Khajoor*

Diderma effusum (Schwein.) Morgan	Pin Head Spot
Graphiola phoenicis (Moug.) Poit.	False Smut
Pestalotia palmarum Cooke	Grey Blight
Polyporus adustus (Willd.) Fr.	Spongy White Rot

Phoenix sylvestris roxb. Wilddate, Talipot palm

Exosporium palmivorum Sacc.	Leaf Splitting
Grammothele cineracea Bres.	Pin Head Spot
Graphiola applanata Syd. and Butler	Pin Head Spot
Graphiola phoenicis (Moug.) Poit.	False Smut
Meliola amphitricha Fr.	Sooty Mould
Meliola palmicola Wint.	Sooty Mould
Pestalotia palmarum Cooke	Grey Blight

Phyllanthus emblica L. *Awla*

Phakopsora phyllanthi Diet	Leaf Rust
Ravenelia emblicae Syd.	Ring Rust

Picea morinda Link

Armillaria mellea (Vahl) Quel.	Armillaria Root Rot
Chrysomyxa deformans (Diet) Jac.	Needle Rust
Chrysomyxa piceae Barclay	Needle Rust
Collybia velutipes (Curt.) Fr.	Soft Spongy White Sap Rot
Fomes annosus Fr.	Annosus Bult Rot
,, *fomentarius* (L.) Fr.	Heart Rot
,, *geotropus* Cke.	Butt Rot (Brown pocket Heart Rot)
,, *igniarius* (L.) Fr.	False Tinder Fungus, White Trunk Heart Rot
,, *pinicola* Fr.	Red Belt Fungus
,, *roseus* Fr.	Brown Cubical Heart Rot
Lenzites abietina Fr.	Albietinus Rot or Brown Pocket Rot
,, *betulina* (L.) Fr.	White Spongy Rot
,, *subferruginea* Berk.	Dry Rot (Brown Cubical Rot)
Merulius tremellosus Fr.	White Pocket Rot
Peridermium piceae Barclay	Needle Rust
,, *thomsoni* Berk Apud Cke.	Needle Rust
Pleurotus ostreatus (Jacq.) Fr.	White Flaky Sap and Heart Rot
Polyporus abietinus (Dicks.) Fr.	Albietinus Rot or Hollow Pocket Rot
,, *dichrous* Fr.	White Spongy Rot
,, *friabilis* Bose	White Spongy Rot
Polystictus elongatus Berk.	Pitted Sap Rot
,, *hirsutus* Fr.	White Spongy Sap Rot

Picea morinda Link—*contd.*

Polystictus leoninus Kl.	White Spongy Rot
,, *versicolor* (L.) Fr.	White Spongy Rot
Poria eupora Karst.	White Sap Rot
Stereum fasciatum Schw.	White Spongy Rot
Trametes pini (Brot) Fr.	Red Ring Rot

Pieris ovalifolia D. Don.

Exobasidium pieridis P. Henn.	Black Leaf Spot
Fomes conchatus (Pers.) Fr.	White Sap and Heart Rot
Ganoderma applanatum (Pers.) Pat.	White Sap and Heart Rot
Rhytisma piceum Berk.	Tar Spot

Pinus excelsa Wall.

Capnodium pini Berk. et Curt.	Sooty Mould
Fomes annosus Fr.	Annosus Butt Rot
,, *fomentarius* (L.) Fr.	Heart Rot
,, *geotropus* Cke.	Butt Rot (Brown Pocket Heart Rot)
Lenzites repanda (Mont.) Fr.	White Spongy Sap Rot
,, *sepiaria* Fr.	Dry Rot, Brown Cubical Rot
,, *subferruginea* Berk.	Do.
Lophodermium pinastri (Schrad) Chev.	Needle Cast
Peridermium brevius (Barcl.) Sacc.	Needle Rust
,, *indicum* Colley and Taylor	Stem Rust
Polyporus abietinus (Dicks.) Fr.	Hollow Pocket Rot
Polyporus circinatus Fr.	White Pocket Rot
Polystictus elongatus Berk.	Pitted Sap Rot
,, *hirsutus* Fr.	White Spongy Sap Rot
Stereum fuscum (Sch.) Quel.	White Spongy to Fibrous Rot
Trametes pini (Brot.) Fr.	Red Ring Rot

Pinus girardiana Wall.

Trametes pini (Brot) Fr.	Red Ring Rot

Pinus insularis Endn.

Coleosporium senecionis (Pers.) Fries	Needle Rust
Cronartium quecuum (Berk.) Miyabe	Gall Rust
Fomes pinicola Fr.	Red Belt Fungus

Pinus khasya Royle

Fomes pinicola Fr.	Red Belt Fungus

Pinus longifolia Roxb. *Chil*

Coleosporium campanulae (Pers.) Lev.	Rust
Cronartium himalayense Bagchee	Blister Rust
Fomes annosus Fr.	Annosus Butt Rot
Fomes pinicola Fr.	Brown Crumbly Rot
Ganoderma applanatum (Pers.) Pat.	White Sap and Heart Rot
Lenzites adusta Massee	White Creamish Spongy Rot
Lenzites sepiaria Fr.	Dry Rot

Pinus Longifolia Roxb. Ihil—*contd.*

Lenzites striata Swartz	Dry Rot
Lenzites subferruginea Berk.	Dry Rot
Lophodermium pinastri (Schrod.) Chev.	Needle Cast
Peridermium himalayense Bagchee	Stem Rust
Polystictus abietinis Fr.	Spongy Sap Rot
,, *hirsutus* Fr.	White Spongy Sap Rot
,, *versicolor* (L.) Fr.	White Spongy Rot
,, *vinosus* (Berk.) Cooke	White Spongy Rot
Schizophyllum commune Fr.	Superficial Sap Rot
Septoria pisi West	Leaf Spot
Trametes lactinea Berk.	White Spongy Rot
,, *pini* (Brot.) Fr.	Red Ring Rot

Piper betle L. Betel leaf, *Pan*

Asteroma piperis Allesch.	Anthracnose
Colletotrichum piperis Petch	Anthracnose
Glomerella cingulata (Stonem.) Spauld. and V. Schrenk	Anthracnose
Phytophthora parasitica Dastur	Blight
,, *parasitica* Dast. var. *piperina* Dast.	Blight
Pythium piperina Dastur	Root Rot
Rhizoctonia solani Kuhn	Root Rot
Sclerotium rolfsii Sacc.	White Rot

Piper nigrum L. Black peppar, *gol mirach*

Colletotrichum necator Massee	Anthracnose
Rosellinia bunodes (Berk. and Br.) Sacc	Collar Rot

Pisum sativum L. garden pea, *matar.*

Ascochyta pisi Lib.	Leaf and Pod Spot
Ascochyta pinodella Jones	Foot Rot
Cercospora pisi-sativae Stevenson	Leaf Spot
Erysiphe polygoni DC	Mildew
Peronospora pisi Syd.	Downy Mildew
Uromyces fabae (Pers.) de Bary	Rust

Pithecolobium dulce Benth.

Phyllosticta inga-dulcis Diedicke	Leaf Spot

Pongamia glabra Vent. Indian beach

Ganoderma lucidum (Leyss.) Karst.	White Rot
Phyllachora pongamiae (Berk. and Br.) P. Henn	Leaf Tar Spot

Populus alba Linn.

Melampsora rostrupii G. Wagner	Leaf Rust

Populus ciliata Wall.

Boerlagella effusa Syd. and Butler	Stem Crust

Populus ciliata Wall—*contd.*	
Melampsora ciliata Barclay . . .	Rust
Prunus armeniaca L. Apricot, *Khubani*	
Nectria cinnabarina (Tode) Fr. . .	Coral Spot of Wood
Phyllosticta prunicola (Opiz) Sacc. . .	Brown Patch Rot of Leaf
Polyporus hispidus (Bull.) Fr. . .	Spongy Heart Rot
Puccinia pruni—spinosae Pers. . .	Brown Rust
Prunus communis Frit.	
Clasterosporium carpophilum (Lev.) Aderhold	Shot Hole
Fomes lividus Kl.	White Spongy Rot
Phyllosticta prunicola (Opiz) Sacc. . .	Brown Patchy Rot of Leaf
Puccinia pruni-spinosae Pers. . .	Brown Rust
Sphaerotheca pannosa (Wallr.) Lev. .	Mildew
Prunus cornuta Wall.	
Asterostromella rhodospora Wakef. . .	White Spongy Rot
Prunus puddum Roxb.	
Polystictus hirsutus Fr.	White Spongy Sap Rot
Prunus persica Stokes Peach, *Aroo* .	
Botryodiplodia persicae Diedicke . .	Die Back
Botryosphaeria pruni-spinosae Delacr. .	Die Back
Cladosporium carpophilum Thum. . .	Shot Hole
Coniothecium chomatosporum Corda . .	Stem Black
Fomes senex Nees and Mont. . . .	White Sap and Heart Rot
Phyllosticta persicae Sacc. . . .	Brown Patch Rot of Leaf
Polyporus ostreiformis Berk. . . .	White Sap Rot
Polystictus hirsutus Fr.	White Spongy Sap Rot
Puccinia pruni-persicae Hori . . .	Brown Rust
,, *pruni-spinosae* Pers. . . .	Brown Rust
Sphaerotheca pannosa (Wallr.) Lev. . .	Mildew
Taphrina deformans (Berk.) Tul. . .	Leaf Curl
Psidium guyava L. guava, per, *Amaruth*	
Meliola psidii Patouill	Sooty Mould
Pestalotia psidii Patouill . . .	Grey Blight
Punica granatum L. Pomegranate, *Anar*	
Aspergillus castaneus Patterson . .	Mouldy Fruit Rot
Aspergillus niger von Tieghem . .	Mouldy Fruit Rot
Cercospora punicae P. Henn. . . .	Leaf and Fruit Spot
Pyrus communis L. Pear, *Nashpati*	
Aspergillus japonicus Saito . . .	Black Fruit Rot
Entomosporium maculatum Lev. . .	Leaf Blight
Fomes senex Nees and Mont. . .	White Sap and Heart Rot
Nectria cinnabarina (Tode) Fr. . . .	Coral Spot
Pellicularia salmonicolor (B. & Br.) Dast.	Pink Disease

Pyrus communis L. Pear *Nashpati—contd.*

Phyllactinia corylea (Pers.) Karst	Mildew
Phyllosticta prunicola (Opiz) Sacc.	Brown Patchy Rot

Pyrus malus L.

Botryosphaeria ribes (G. and D.)	Stem Brown
Coniothecium chomtosporum Corda	Stem Black
Glutinium macrosporum Zeller	Bark Canker
Myxosporium microsporum Cke. and Harker	Leaf Spot
Pellicularia salmonicolor (B. & Br.) Dast.	Pink Disease
Sphaeropsis malorum Berk.	Stem Canker

Quercus dilata Lindl.

Asterostromella rhodospora Wakef.	White Spongy Rot
Fomes fomentarus (L.) Fr.	Heart Rot
Lenzites repanda (Mont.) Fr.	White Spongy Sap Rot
Polyporus adustus (Willd.) Fr.	White Sap Rot
Polystictus elongatus Fr.	White Pocket Sap Rot
,, *versicolor* (L.) Fr.	White Pocket Sap Rot
Stereum hirsutum (Willd.) Fr.	Piped Rot
,, *lobatum* Fr.	White Spongy Rot
,, *rugosum* (Pers.) Fr.	White Spongy Rot
Trametes dickinsii Berk.	Brown Crumbly Rot

Quercus incana Roxb.

Bulgaria polymorpha (Oed.) Wett.	Superficial Sap Rot
Fomes annosus Fr.	Annosus Butt Rot
,, *caryophylli* (Rai) Bres.	Pitted Rot
,, *conchatus* (Pers.) Fr.	White Sap and Heart Spongy Rot
,, *senex* Nees and Mont.	White Sap and Heart Rot
Hydnum erinaceus Bull.	Hedge Hog Fungus, White Rot of Heart Wood
Hymenochaete tabacina Fr.	White Spongy Rot
Merulius tremelosus Fr.	White Spongy Slot Rot
Polyporus cuticularis (Bull) Fr.	White Spongy Rot
,, *gilvus* Schw.	White Spongy Rot
Polystictus elongatus Berk.	White Pocket Rot
,, *hirsutus* Fr.	Soft Spongy Sap Rot
,, *versicolor* (L.) Fr.	White Spongy Sap Rot
,, *xeranticus* Berk.	White Pocket Rot
Stereum fasciatum Schw.	White Spongy Rot
,, *hirsutum* (Willd.) Fr.	Piped Rot
,, *lobatum* Fr.	White Spongy Rot
,, *princeps* Jungh.	Sap and Heart Pocket Rot

Quercus semecarpifolia Smith.

Asterostromella rhodospora Wakef.	White Spongy Rot
Fomes conchatus (Pers.) Fr.	White Sap and Heart Rot
,, *rimosus* Berk.	Spongy Yellow Heart Rot
,, *senex* Nees and Mont.	White Sap and Heart Rot
Hymenochaete rubiginosa (Schrad.) Lev.	White Pocket Rot
Lenzites botulina (L.) Fr.	White Spongy Rot
Merulius tremellosus Fr.	White Spongy Slash Rot
Polyporus adustus (Willd.) Fr.	White Sap Rot
,, *cuticularis* (Bull.) Fr.	White Spongy Rot
,, *gilvus* Schw.	White Spongy Rot
,, *sulphureus* (Bull.) Fr.	Heart Rot
Polystictus elongatus Berk.	White Pitted Sap Rot
,, *versicolor* (L.) Fr.	White Spongy Sap Rot
,, *xeranticus* Berk.	White Pocket Rot
Stereum hirsutum (Willd.) Fr.	Piped Rot
,, *princeps* Jungh.	Sap and Heart Pocket Rot
,, *rugosum* Pers.	White Spongy Rot
Trametes dickinsii Berk.	Brown Crumbly Rot
,, *mollis* Fr.	White Spongy Rot

Raphanus sativus L. var. *caudatus*. Rat tail radish

Cystopus candidus (Pers.) Lev.	White Blister
Peronospora brassicae Gaumann.	Downy Mildew

Rhododendron arboreum Sm.

Chrysomyxa dietelii Syd.	Leaf Rust
,, *himalensis* Barclay	Witch's Brown Rust
Exobasidium butleri Syd.	White Crust
Stereum notatum B. et Br.	Spongy White Rot

Rhus parviflora Roxb.

Fomes conchatus (Pers.) Fr.	White Sap and Heart Spongy Rot

Rhus punjabensis Stewart.

Fomes conchatus (Pers.) Fr.	White Sap and Heart Spongy Rot
,, *senex* Nees and Mont.	White Sap and Heart Rot
Stereum frustulosum (Pers.) Fr.	Partridge Wood Rot

Ribes rubrum Linn.

Cronartium ribicola Fisch.	Leaf Rust

Ricinus communis L. Castor, *Erand*

Melampsora ricini (Biv.) Pers.	Rust
Phytophthora parasitica Dastur	Seedling Blight
Pythium aphanidermatum (Eds.) Fitz.	Damping Off

Rosa spp.

Cercospora rosicola Thum.	Leaf Spot
Diplocarpon rosae Wolf	Black Spot
Massaria marginata Fuckel	Brown Twig Spots
Phragmidium butleri Syd.	Rust
,, *disciflorum* (Tode) James	Rust
Septoria rosae Desm.	Leaf Scorch
,, *rosarum* West.	Brown Leaf Spot
Sphaerotheca pannosa (Wallr.) Lev.	Mildew

Rubus lasiocarpus Smith

Phragmidium assamens Syd.	Rust
,, *barclayi* Diet.	Rust

Saccharum munja Roxb.

Sorosporium indicum Mundkur	Smut

Saccharum officinarum L. Sugar cane, *Eckh*

Botryodiplodia saccharina Diedicke	Dry Rot
Botryodiplodia theobromae Patouill.	Dry Rot
Cephalosporium sacchari Butler	Wilt
Ceratostomella adiposum (Butler) Sartoris	Black Rot
Ceratostomella paradoxa (de Seynes) Dade	Pine Apple Disease
Cercospora kopkeii Krueg	Yellow Spot
,, *longipes* Butler	Brown Spot
,, *vaginae* Krueg.	Leaf sheath red Spot
Colletotrichum falcatum Went	Red Rot
Cytospora sacchari Butler	Stem Canker
Fusarium moniliforme Sheldon	Top Rot
Helminthosporium sacchari Butler	Eye Spot
Hendersonina sacchari Butler	Collar Rot
Leptosphaeria sacchari Breda de Haan	Rind Spot
Meliola sacchari Syd.	Sooty Mould
Phytomonas rubriliaeanious Lee and Jennings	Red Stripe
Pleocyta sacchari (Mass.) Petr. and Syd.	Pink Disease
Rhizoctonia solani Kuhn	Banded sclerotial Disease
Saccharum virus I Smith	Mosaic
Sclerospora sacchari Miyake	Downy Mildew
Sphacelotheca sacchari (Rabenh.) Ciferri	Arrow Smut

Saccharum officinarum L. Sugar cane.

Ustilago scitaminea Syd. . . . Whip Smut
" " " var. *sacchari-barberi* Mundkur Whip Smut
" " " var. *sacharri-officinarum* Mundkur . Whip Smut
Zea virus II Smith . . . . Streak

Saccharum spontaneum L.

Ustilago scitaminea Syd. . . . Whip Smut
" " " var. *sacchari-barberi* Mundkur . . Whip Smut

Santalum album L. sandalwood tree .

Ganoderma applanatum (Pers.) Pat. . White Sap and Heart Rot

Schleichera trijuga Willd.

Hexagonia apiaria Pers. . . . White Spongy Rot
Rosellinia bunodes (B. et Br.) Sacc. . Stem Blight

Scutellaria angulosa Benth

Aecidium scutellariae Syd. . . . Leaf Rust

Sesamum orientale L. (S. *indicum* L.)

Sesame, *Til*, *Gingelly*
Cercospora sesami Zimm. . . . Leaf Spot
Macrophomina phaseoli(Maubl.) Ashby . Dry Root Rot
Phytophthora parsitica Dastur . . Leaf Blight

Shorea assamica Dyer.

Fomes melanoporus Mont. . . . Butt Rot
Ganoderma applanatum (Pers.) Pat. . White Sap and Heart Rot

Shorea robusta Gaertn.

Daedalea flavida Lev. . . . . White Spongy Rot
Daldinia eschscholzii (Ehrenb.) Rehm. . Superficial White Rot
Fomes albomarginatus (Lev.) Cooke . White Pocket Rot
" *durissimus* Lloyd . . . White Spongy Sap and Heart Rot
" *fastuosus* Lev. . . . . White Pocket Heart Rot
" *lamaoensis* (Murr.) Sacc. and Trott. . . . . Honey-combed Rot
" *lignosus* Klot. . . . . Brown cubical Rot
" *lividus* Kalchb. . . . . White Fibrous Rot
" *melanoporus* Mont. . . . Butt Rot
" *rimosus* (Berk.) Cook. . . . Spongy Yellow Heart Rot
" sp. . . . . Pox Rot
" *tricolor* (Murr.) Bres. . . Yellowish Sap Rot
Ganoderma applanatum (Pers.) Pat. . . White Sap and Heart Rot

Shorea robusta Gaertn—*contd.*

Hexagonia discopoda Pat. and Har.	White Spongy Sap Rot
,, *sulcata* Berk.	Brown Cubical Rot
Hymenochaete rubiginosa (Schnad.) Lev.	White Pocket Rot
Irpex flavus Klot.	White Spongy Sap and Heart Rot
Lenzites adusta Massee.	White Spongy Rot
,, *flaccida* (Bul.) Fr.	White Spongy Fibrous Sap and Heart Rot
Lentinus praerigidus Berk.	White Spongy Fibrous Rot
,, *subnudus* Berk.	White Spongy Sap and Heart Rot
Polyporus adustus (Willd.) Fr.	White Spongy Slash Rot
,, *agaricus* Berk.	White Spongy Rot
,, *anebus* Berk.	White Spongy Sap Rot
,, *gilvus* Schwein.	Sap and Heart White Pocket Rot
,, *ostreiformis* Berk.	Brown Fibrous Rot
,, *shoreae* Wakef.	Partridge Butt Rot
Polystictus cingulatus Fr.	White Fibrous Rot
,, *flabelliformis* Klotzsch.	White Creamish Spongy Rot
,, *hirsutus* Fr.	Spongy Sap Rot
,, *sanguineus* (L.) Mey.	White Spongy Rot
,, *steinheilianus* Berk. and Lev.	White Spongy Rot
,, *tabacinus* Mont.	Specked Brown Rot
,, *venulosus* Jungh.	White Spongy Rot
,, *versatilis* Berk.	Sap and Heart Pocket Rot
,, *versicolor* (L.) Fr.	Spongy Rot
,, *vinosus* (Berk.)	White Spongy Rot
,, *xanthopus* Fr.	White Spongy Rot
Stereum hirsutum (Willd.) Fr.	White Spongy Slash Rot
,, *lobatum* Fr.	White Spongy Slash Rot
,, *percome* Berk. and Br.	Sap and Heart Fibrous Rot
Trametes cingulata Berk.	Spongy to Fibrous Rot
,, *cubensis* Mont.	Brown Cubical Rot
,, *fuscella* Lev.	White Spongy Rot
,, *incerta* (Currey) Cke.	Brown Spongy Heart Rot
,, *lactinea* Berk.	White Spongy Rot
,, *persoonii* Fr.	White Spongy Rot
,, *spongpellis* Lloyd	Brown Cubic Rot
,, *versatilis* Berk.	White Pocket Rot

Solanum melongena L. Egg plant, Brinjal, *Baigan*

Aecidium tubulosum Patouill and Gaill	Rust
Alternaria solani (Ell. and Mart.) Jones and Grout	Early Blight

Solanum melongena L. Egg plant, Brinjal, *Baigan*—contd.	
Cercospora feuilleauboisii Sacc.	Leaf Spot
,, *solani* Sacc.	Leaf Spot
Leveilulla taurica (Lev.) Arnaud	Mildew
Macrophomina phaseoli (Maubl.) Ashby.	Dry Root Rot
Phoma solani Cooke and Hark	Stem Blight
Solanum tuberosum L. Potato, *Alu*	
Actinomyces scabies (Thaxt.) Gussow.	Common Scab
Alternaria solani (Ell. and Mart.) Jones and Grout	Early Blight
Cercospora concors (Casp.) Sacc.	Yellow Leaf Spot
Fusarium coeruleum (Lib.) Sacc.	Dry Rot
,, *oxysporum* Schilecht.	Wilt
,, *javanicum* Koord. var *radicicola* Wollenw.	Black Stem and Rot
,, *tricothecioides* Wollenw.	Powdery Dry Rot
Macrophomina phaseoli (Maubl.) Ashby	Dry Root Rot
Phytophthora infestans (Mont.) de Bary	Late Blight
Pseudomonas Solanacearum (Smith) Dowson	Brown Rot
Sclerotium rolfsii Sacc.	Black Scarf
Spongospora subterranea (Wallr.) Johnson	Powdery Scab
Sorghum halepense Pers. Johnson grass	
Puccinia purpurea Cooke	Rust
Sclerospora graminicola (Sacc.) Schroeter	Downy Mildew
,, *sorghi-vulgaris* (Kulkarni) Mundkur	Downy Mildew
Sphacelotheca cruenta (Kuhn.) Potter	Loose Smut
,, *sorghi* (Link.) Clinton	Grain Smut
Sorghum vulgare Pers.	
Colletotrichum graminicolum (Ces.) Wilson	Red Leaf Spot
Helminthosporium turcicum Pass.	Leaf Blight
Macrophomina phaseoli (Maubl.) Ashby	Dry Root Rot
Puccinia purpurea Cke.	Rust
Sclerospora andropogonis-sorghi (Kulkarni) Mundkur	Downy Mildew
Sphacelotheca cruenta (Kuhn.) Potter	Loose Smut
,, *sorghi* (Link.) Clinton	Grain Smut
Tolyposporium Ehrenberhii (Kuhn.) Patouill	Long Smut

Sterculia alata Roxb.

Fomes lamaoensis (Murr.) Sacc. . . Honey-combed Rot
Polystictus occidentalis Kbotlsch. . . White Spongy Rot
Trametes persoonii Fr. . . . White Spongy Rot

Stereospermum suaveolens DC.

Mehtamyces steriospermi Mundkur . . Rust

Swertia chirata Ham.

Chirata and thirumalachar
Cronartium himalayense Bagchee . . Rust

Swietenia mahagoni Linn.

Daedalia flavida Lev. . . . White Spongy Rot
Dothiorella mahagani Thun. . . . Black Spot of Stem
Fomes durissimus Lloyd. . . . White Spongy Sap and Heart Rot
,, *fastuosus* Lev. . . . . White Pocket Rot

Taxus baccata Linn.

Asterostromella rhodospora Wakef. . White Soft Fibrous Rot
Diaporthe taxicola Sacc. and Syd. . Bark Spot
Lenzites abietinus Fr. . . . . Brown Cubical Rot
Sirothyrium kaxi Syd. . . . . Needle Spot
Stereum frustolsum (Pers.) Fr. . . Partridge Wood Rot

Tectona grandis L.

Daedalia flavida Lev. . . . White Spongy Rot
Ganoderma applanatum (Pers.) Pat. . White Sap and Heart Rot
Irpex flavus Klot. . . . . White Spongy Rot
Nectria haematococeus Berk. et Br. . . Canker
Polyporus adustus (Willd.) Fr. . . White Spongy Rot
Uncinula tectonae Salmon . . Mildew
Uredo tectonae Rac. . . . . Brown Rust

Terminalia belerica Roxb.

Cercospora terinaliae. Syd. . . . Leaf Spot
Fomes rimosus Berk. . . . . Spongy Yellow Heart Rot
Trametes lactinia Berk. . . . White Spongy Rot

Terminalia catappa Linn.

Fomes fastuosus Lev. . . . . Brown Pocket Rot of Heart Wood
Gleosporium terminaliae Syd. and Butler . . . . . Leaf Spot
Meliola amphitricha Fr. . . . Sooty Mould
Phyllosticta catappae Syd. . . . . Leaf Spot
Polyporus gilvus (Schw.) Fr. . . White Spongy Rot
Polyrhizon terminaliae Syd. . . Leaf Spot

Terminalia myriocarpa Heurck and Muellarg

Sehizophyllum commune Fr. . . . White Superficial Rot

Terminalia paniculata W. and A.

Daedalia flavida Lev.	White Spongy Rot
Fomes fastuosus Lev.	White Pocket Rot
Lentinus praerigidus Berk.	White Spongy Rot
Polyporus gilvus (Schw.) Fr.	White Spongy Rot
Polystictus tabacinus Mont.	Speckled Brown Rot
Trametes persoonii. Fr.	White Spongy Rot

Terminalia tomentosa W. and A.

Daedalia flavida Lev.	White Spongy Rot
Fomes melanoporus Mont.	Butt Rot
,, *rimosus* Berk.	Spongy Yellow Heart Rot
Ganoderma lucidum (Leyss) Karst.	White Sap and Heart Rot
Irpex flavus Kl.	White Spongy Sap Rot
Polystictus hirsutus Fr.	White Sap Rot
Trametes straminea (Pat.) Lloyd.	Brown Rot

Theobroma cacao L. cocoa

Phytophthora palmivora Butler	Pod Rot

Trichosanthes anguina L. Snake gourd,

Cercospora trichosanthis McRae	Leaf Spot
Erysiphe cichoracearum DC	Mildew

Trichosanthes dioica Roxb. Potal *Parwal*

Erysiphe cichoracerum DC.	Mildew

Trifolium alexandrianum L. clover *Berseem*

Dothidiella trifolii (Pers.) Bayliss-Elliot and Stansfield	Black Blotch
Rhizoctonia solani Kuhn	Brown Root Rot
Sclerotinia sclerotiorum (Lib.) de Bary	Stem Rot

Trifolium resupinatum L. *Shaftal*

Dothidiella trifolli (Pers.) Bayliss-Elliott and Stanfield	Black Blotch
Peronospora trifolii-repentis Syd.	Downy Mildew
Uromyces trifolii (Hedw. f.) Lev.	Rust
Uromyces minor Schroet.	Rust

Trigonella foenum-graecum L. Fenugreck, *Methi*

Cercospora traversiana Sacc.	Leaf Spot
Erysiphe polygoni DC.	Mildew

Trigonella foenum-graecum L. Fenugreek, *Methi*—contd.

Peronospora trigonella Gaumann	Downy Mildew
Uromyces anthyllidis (Grey) Schroet.	Rust

Triticum vulgare Vill. Wheat, *Gehun*

Erysiphe graminis DC	Mildew
Helminthosporium sativum P., K. & B.	Foot Rot
Neovossia indica (Mitra) Mundkur	Karnal Bunt
Puccinia graminis Pers	Black Rust
Puccinia glumarum (Schm.) Erikss. & Henn	Yellow Rust
Puccinia triticina Erikss.	Brown Rust
Septoria tritici Rob. & Desm.	Leaf Spot
Tilletia caries (DC) Tul.	Bunt
Tilletia foetens (Berk. & Curt.) Trel.	Bunt
Urocystis tritici Koern.	Flag Smut
Ustilago tritici (Pers.) Roster.	Loose Smut
Coryne-bacterium tritici (Mutch) Bergey et al	Tundu

Vateria indica Linn.

Lentinus praerigidus Berk.	White Spongy Rot
Polyporus gilvus (Schw.) Fr.	White Spongy Rot
Polystictus flabelliformis Klotzsch	White Creamish Spongy Rot

Vicia faba L. Horse bean, Broad bean

Alternaria brassicae (Berk.) Sacc. var. *phaseoli* Brun.	Leaf Spot
Erysiphe polygoni DC.	Mildew
Uromyces fabae (Pers.) de Bary	Rust

Vigna unguiculata (L.) Walp. Cowpea, *Barbati*

Macrophomina phaseoli (Maubl.) Ashby.	Dry Root Rot
Uromyces appendiculatus (Pers., Link)	Rust

Vitis vinifera L. Grape vine, *Angur, Draksha*

Gloeosporium ampelophagum (de Bary) Sacc.	Anthracnose
Gloeosporium rufomaculans (Berk.) Thum.	Ripe Rot
Guignardia bidwelli (Pass.) Viola and Ravaz	Black Rot
Plasmospara viticola Berk. and Curt.	Downy Mildew
Uncinula necator (Schw.) Burr.	Mildew

Xylia xylocarpa Taub.

Fomes fastuosus Lev.	White Pocket Rot
Polystictus steinheilianus Berk.	White Spongy Rot
Trametes serpens Fr.	White Spongy Rot

Zea mays L. Corn, *Makai*

Botryodiplodia theobromae Patouill . .	Cob Rot
Colletotrichum graminicolum (Ces.) Wilson..	Red Leaf Spot
Helminthosporium turcicum Pass. . .	Leaf Blight
Physoderma maydis Miyabe : . .	Brown Spot
Puccinia sorghi Schw.	Rust
Sclerospora philippinensis Weston . .	Downy Mildew
,, *andropogonis-sorghi* (Kulkarni) Mundkur . . .	Downy Mildew
Sorosporium reilianum (Kuehn) McAlpine .	Head Smut
Ustilago zea (Beckm.) Unger . . .	Smut

Zingiber officinalis Rosc. Ginger, *Sunth, Adrak*

Colletotrichum zingiberis (Sunderam.) Butler and Bisby	Anthracnose
Helminthosporium maydis Nishik. and Miy.	Leaf Spot
Pythium aphanidermatum (Eds.) Fitzpatrick.	Soft Rot
Pythium graminicolum Subram. . .	Rhizome Rot

Zizyphus jujuba Lamk. *Ber, Bor*

Cladosporium zizyphi Karst. . . .	Leaf Mould
Eutypella zizyphi Syd. and Butler . .	Twig Blight
Oidium erysiphoides Fr.	Mildew
Phakopsora zizyphi-vulgaris (P. Henn.) Diet	Rust

A PRELIMINARY STUDY IN DROUGHT RESISTANCE OF SUGARCANE*

By A. K. Mallik, Agricultural Meteorology Section, Meteorological Office, Poona

DROUGHT is an important problem for agriculturists in general and is of vital importance to farmers of arid tracts, not provided with an elaborate irrigation system. Plant breeders are thus very often called upon to develop drought resistant varieties and sometimes they have to wait for a suitable season for testing the performance of the drought resistant varieties developed by them.

The present investigation deals with the testing of two varieties of sugarcane for drought resistance using a very simple method which can be adopted for any other crop plant.

Drought can be of two kinds :

(1) Aerial drought brought about by an excessive loss of water by transpiration due to a high evaporating power of the air layers near the ground during certain seasons and

(2) Soil drought due to the insufficiency of available water in the soil.

In the present paper the behaviour of two varieties of sugarcane Co. 421 *Saccharum officinarum* Linn. and *Saccharum spontaneum* Linn. subjected to aerial drought, is discussed. The two varieties of cane of which Co. 421 was reported to be a drought resistant variety, were kindly supplied by Sir T. S. Venkataraman, late Imperial Sugarcane Specialist, Coimbatore.

Experimental method

The plants were grown in cylindrical galvanized iron containers 15 inches in diameter and 18 inches high provided with lids. Suitable perforations were made in the lids for the canes to come out and for watering. The pots were filled with black cotton soil of Poona to which farm yard manure, about 10 per cent by weight, was added. The method of watering was from top of the pots through two tubes passing through the lids. These tubes delivered water into a layer of pebbles and sand at the bottom of the soil column in the pot. The sets were planted in the pots on the 13th March, 1942, taking care that there was only one bud in each pot. Four pots were planted with each of the two varieties. Developmental observations were taken regularly. Table I gives the mean values of the growth features, two months after planting, just before the plants were exposed to drought.

*Reprinted from *the Indian Ecologist*, 1, No. 1, April, 1946.

TABLE I

Mean values of four plants on 12-5-42

Co. 421			*Saccharum spontaneum* Linn.		
Height of the cane in cm.	Number of fully open green leaves	Total green leaf area in sq. cm.	Height of the cane in cm.	Number of fully open green leaves	Total green leaf area in sq. cm.
27·5	8	503	15·1	7	32

For exposing the plants to drought the following procedure was adopted. An area 6 ft. by 6 ft. was surrounded, except at the top, by *khas khas tatties* 6 ft. high which were kept wet by a continuous flow of water from a system of perforated pipes fixed all along the tops of *tatties*; the flow of water was maintained from 8 a.m. to 5 p.m. daily. The control area freely exposed to weather, was selected at some distance due south of the humid area. The prevailing winds W to SW, thus precluded the humid air affecting the control plot.

Dry bulb and wet bulb temperatures were recorded with the help of an Assmann psychrometer every hour from 8 a.m. to 5 p.m. daily both in the humid as well as in the dry plots. From these readings the mean values for the day of (1) air temperature, (2) relative humidity and (3) saturation deficit were computed. In addition to these, a Piche evaporimeter was hung in each plot and hourly values of evaporation as well as the total evaporation between 8 a.m. and 5 p.m. under the two kinds of exposures from 13-5-42 to 16-5-42, the period during which the plants were exposed to drought were obtained.

TABLE II

Mean value for the day of meteorological elements in the humid and dry plots

Date	Temperature in (°)C.		Relative humidity per cent		Saturation deficit in gm. of water vapour		Evaporation in 24 hours in c.c.	
	Humid	Dry	Humid	Dry	Humid	Dry	Humid	Dry
13-5-42	32·0	35·6	30	18	25·0	35·7	14·0	33·8
14-5-42	32·2	36·1	32	21	24·6	35·5	11·1	25·6
15-5-42	31·2	35·1	40	34	18·4	27·9	8·6	20·4
16-5-42	27·8	31·5	50	45	11·5	19·0	7·6	17·9

It is seen from Table II that the temperature, suturation deficit and therefore evaporation are markedly lower in the plot surrounded by the *khas khas tatties* than in the open.

Before exposing the plants to drought, the tillers if any, were cut off and then the containers were sealed vapour tight so that no loss of water except as transpiration, could take place. Water was then added so as to bring up the moisture percentage of the soil to 15 per cent in all the pots and weights of the pots were then recorded. Two containers of each variety were placed in the humid plot surrounded by the wet *khas khas tatties* the other two being kept in the control plot. Every day at 8 a.m. the pots with the plants were weighed, water was then added and the weights after adding water was recorded. The amount of water transpired was obtained by deducting from the second weight of the day the first weight of the next day. The amount of water lost as transpiration was made good so that the moisture percentage of the soil remained at 15 per cent from day to day. To give an example, transpiration for the sixteenth was equal to weight after adding water on the sixteenth minus weight before adding water on the seventeenth.

Table III gives the mean values for each day of (1) transpiration in gm. per sq. cm. of green leaf area for the two varieties of sugarcane under the two conditions of exposure, (2) evaporation per sq. cm. of evaporating surface from Piche's evaporimeter under the dry and humid conditions and (3) the relative transpiration of Livingston, i.e., the ratio of transpiration to evaporation for the two varieties under the two (humid and dry) conditions of exposure.

TABLE III

Mean values

Date	Transpiration in gm. per sq. cm. of leaf area				Evaporation in gms. per sq. cm. of exposed surface (Piche)		Relative transpiration = Transpiration/Evaporation			
	Co. 421		*Saccharum spontaneum*				Co. 421		*Saccharum spontaneum*	
	Humid exposure	Dry exposure	Humid exposure	Dry exposure	Humid exposure	Dry exposure	Humid exposure	Dry exposure	Humid exposure	Dry exposure
13-5-42	0·32	0·37	0·81	1·86	1·07	2·59	0·30	0·14	0·77	0·72
14-5-42	0·31	0·37	0·68	1·67	0·85	1·96	0·36	0·19	0·81	0·87
15-5-42	0·25	0·32	0·65	1·33	0·66	1·56	0·38	0·20	1·00	0·87
16-5-42	0·23	0·29	0·43	1·14	0·58	1·37	0·39	0·21	0·72	0·81
	0·28	0·34	0·64	1·50	0·79	1·87	0·36	0·19	0·83	0·82

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Discussion

Table III shows that (1) the relative transpiration is much lower in Co. 421 than in *Saccharum spontaneum* both under arid as well as under humid conditions. This indicates that of the two varieties, Co. 421 shows a better economy of water. (2) However, the most interesting point is the variation in the values of the relative transpiration of the two varieties under the contrasting kinds of exposure. In the case of *Saccharum spontaneum*, it will be noticed that the relative transpiration is more or less the same under humid and arid exposures. This means that the plants transpire like any ordinary evaporimeter losing water and there is not much internal regulation to cut down the transpirational loss when the plants are subjected to arid conditions. In contrast to the above the relative transpiration in the case of Co. 421 is very much smaller under arid than under humid conditions. This is invariably true for all the days on which observations were taken and the mean value under arid conditions (0·19) is practically half of that under humid conditions (0·36). According to Livingston, variation in the relative transpiration is an indication of regulatory activities of the plant, influencing the rate of transpiration. As shown above, relative transpiration in the case of Co. 421 under arid conditions is about half of the under humid conditions, thus definitely indicating the existence of some biological control which tends to cut down the transpirational loss and resists to a large extent, the dessicating influence of a dry atmosphere. Such regulatory activities appear to be absent in the variety *Saccharum spontaneum*. Thus the claim of Co. 421 being a drought resistant variety is substantiated.

The comparatively simple and quick method of testing for drought resistance described above may be of interest to plant breeders breeding crop plants for drought resistance.

Summary

A method is described for testing the resistance of crop plants to aerial drought.

Two varieties of sugarcane Co. 421 and *Saccharum spontaneum* have been tried for drought resistance. It has been shown that (a) the relative transpiration is very much smaller in Co. 421 and (b) the relative transpiration in the case of Co. 421 under dry conditions is found to be about half of that under humid conditions. In the case of *Saccharum spontaneum* the values of relative transpiration are practically the same under dry and humid conditions. Thus Co. 421 appears to be a drought resistant variety.

Acknowledgments

My best thanks are due to Dr L. A. Ramdas for suggesting the problem and for help in developing the method used and to Mr. U. P. Pandit for help in taking some observations.

References

Livingston, B. E. (1907). *Carnegi Inst., Washington, Pub.* **50**, 1-77.

REVIEW

Journal of Soil Science

Edited by G. V. Jacks, Oxford University Press, London, 1949. Vol. 1, pp. 122, Price 17*s*.

THIS is the first issue of the Journal of Soil Science, an organ of the British Society of Soil Science. Its get-up and printing are quite good. The Journal is published bi-annually and two numbers constitute a volume. The present volume contains eleven papers covering wide range of subjects as would appear from the titles of the papers given below : Effect of *p*H on electric charges carried by clay particles ; A climatic index for the leaching factor in soil formation ; Frost soils on Mount Kenya and the relation of frost soils to aeolian deposits ; Geomorphology and soil science ; The association of hydrologic sequence in certain soils of the podzolic zone of north-east Scotland ; Podzolic soils of Wales ; Underwater soils—a review of lake sediments ; The dependence of transpiration on weather and soil conditions ; Some notes on the recording and interpretation of X-ray diagrams of soil clays ; An X-ray diffraction study of humification ; The movement and precipitation of iron oxide in podzol soils. The standard of the papers is high. The scope of the Journal covers the science in its broadest aspects and includes the cognate sciences of ecology, geology and geography in relation to the soil. The new Journal is very welcome and is sure to get wide support. (J.N.M.)

MGIPC—M—180 A R—15-5-51—1,150.

PRIZE.

———:0:———

Messrs. Gardeners Corporation, New Delhi have offered a prize of Rs. 200 per year to the best contributor of an article on 'fruit preservation and canning'. While giving this award they have selected, besides one or two other Journals, the two Journals of the Indian Council of Agricultural Research viz., Indian Journal of Agricultural Science and Indian Farming, out of which, contributors of articles on the subject have to be selected. The award has been given on an annual basis and the first award will be given to the contributor of the best article on the subject during the period 1-1-51 to 31-12-51. To adjudicate articles, a Committee consisting of the following gentlemen has been formed :—

(1) Dr. V. Subrahmanyan, Director, Central Food Technological Research Institute, Mysore,

(2) Dr. Girdhari Lal, Asst. Director (Fruit Technology), Central Food Technological Research Institute, Mysore

AND

(3) Shri Kailash Nath of Messrs. Harnarain Gopi Nath of Delhi and Hony. Secretary, All India Food Preservers' Association, Delhi.

ERRATA

Indian Journal of Agricultural Science
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Page	*Line*	*For*	*Read*
26	2	tooped	topped
26	3 from bottom	sowing	for sowing
26	2 from bottom	harvesting	for harvesting
26	Last	dates	for dates
27	Table III Column 2	29,95	20,995
27	Table IV bottom	$e\ f\ d\ \ c\ b > a$	$e\ f\ d\ \ c\ b > a$
30	Fig. 1	20, 18, 16.....2	2·0, 1·8 ,1·0,..... .2
30	Key to Fig. 1		

End—September sowing————————

Mid—October sowing—— —— ——

End—October sowing.....

Mid—November sowing—— . —— . —

ERRATA

Indian Journal of Agricultural Science
Vol. XIX, Part II, June, 1949

Page	*Line*	*For*	*Read*
181	19	(2)	(ii)
182	Table I, Column I	Lines should be drawn after cottons 6 and 14 in order to indicate the three groups into which the cottons are divided.	
182	Table I, Line 16, Column 3	1938-1939	delete
183	12	fibre	fibres
184	3	were	was
184	19	α	α'
184	20	β	β'
184	21	γ	γ'
185	9	$\frac{\Pi}{4}(D^2-d^2)$	$\frac{\Pi}{4}(D^2-d^2)\rho$
185	28	(D^2-d^2)	$\overline{(D^2-d^2)}$
185	29	(D^2-d^2)	$\overline{(D^2-d^2)}$
191	7 from bottom	weighed	weighted
191	7 from bottom	weighing	weighting
192	Serial No. 16, Column 2	Sake's	Sakels
195	13	$\frac{\pi}{4} D^2\rho M$	$\frac{\pi}{4} \overline{D^2\rho M}$
195	2	$\frac{\pi}{4} D^2\rho M$	$\frac{\pi}{4} \overline{D^2\rho M}$
196	3	or $D=\sqrt{\left\{\frac{3{\cdot}6\ F}{0{\cdot}9558\pi\rho_m M_c}\right\}}$	or $D=\sqrt{\left\{\frac{3{\cdot}6\ F}{0{\cdot}9558\pi\rho_m M_c}\right\}}=1{\cdot}518\sqrt{\frac{F}{M_c}}$
196	15	+	$\pm$
196	15	$\pm$	delete
196	16	+	$\pm$
196	16	+	$\pm$
197	Table V	From fibre-weight maturity Coefficient	From fibre-weight/Maturity Coeffiicent

Page	*Line*	*For*	*Read*
198	Table V	do.	do.
198	Table V	Valves	values
198	Table V, Columns 9 and 10	Ne	New
198	Table V, Column 8, Line 2.	—2·3	—3·2
200	9	198	194—5
200	17	weighing	weighting
200	4 from bottom	weighing	weighting
200	3 from bottom	weighing	weighting
210	1	weighing	weighting
203	2	out	cut
206	20	hygrospicity	hygroscopicity
218	Fig. II A	Graphical representation of the number of nodes, increase in number after every 15 days and average daily increase in the number of nodes	Graphical representation of the height, increase in height after every 15 days and average daily increase in the height
219	Fig. II A		
220	Fig. II B		
222	Fig. III A	Ordinate is missing. It should be the same as that on page 221, fig. III A.	

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